A COMMUNITY HEALTH STUDY OF THE RESIDENTS OF WHITCHURCH-STOUFFVILLE

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A COMMUNITY HEALTH STUDY OF THE RESIDENTS OF WHITCHURCH-STOUFFVILLE

PREPARED FOR: ONTARIO MINISTRY OF HEALTH

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In Whitchurch-Stouffville, the Citizens Advisory Group participated in the study design, and provided support throughout the study. Members of the Group were: Dr. John Hodgkinson, Associate Medical Officer of Health for the Regional Municipality of York, and Chairman of the Group; Mrs. Fran Sainsbury, Mayor of Whitchurch-Stouffville; Mr. James Sanders, Councillor of Whitchurch-Stouffville; Mrs. Anne Gagnon and Mrs. Debi Mitchell of the Concerned Citizens of Whitchurch-Stouffville; and, Dr. J. Owen Slingerland, Commissioner of Health and Social Services, and Medical Officer of Health for the Regional Municipality of York.

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EXECUTIVE SUMMARY

The residents of the Town of Whitchurch-Stouffville (WS) in the Regional Municipality of York, north-east of Metropolitan Toronto, have expressed serious concern about adverse health outcomes possibly due to contaminated drinking water resulting from a local landfill site. The landfill site, operated between 1962 and 1985, had been used for the disposal of domestic and industrial waste. Primarily, as a result of hazardous, industrial waste disposal during the late 1960's and early 1970's, there was local concern that chemicals might be leaching from the site and contaminating drinking water in the area.

THE STUDY:

The Ontario Ministry of Health in collaboration with the Medical Officer of Health and the WS Citizens Advisory Group undertook a community health study of the area. The study was carried out under contract to Goss, Gilroy & Associates Ltd.

The study examined the health status of the residents of WS and two comparison communities, the Town of East Gwillimbury (EG) in the Regional Municipality of York and the Township of Tecumseth (Tec) in Simcoe County. Health status was examined through a survey of a sample of residents from each area selected and an analysis of blood for selected parameters. In addition to the survey data, population data were obtained from several sources: mortality data (based on death certificate information) from Statistics Canada using the Canadian Mortality Database, for the years 1971-1983; cancer incidence data (based on population registry) from the Ontario Cancer Treatment and Research Foundation (OCTRF), and congenital anomalies and reproductive outcome data from the Congenital Anomalies Surveillance System (CASS).

The two comparison areas were selected because they are similar in demographic, social and economic characteristics, and for proximity to WS. Both areas have landfill sites, although EG's site is much smaller

than the one in WS, and Tec's site is a very small domestic waste landfill. WS was subdivided into three areas (A,B,C), which were defined in order of potential high to low risk of contamination of their drinking water. The exposure risk model was developed by MacLaren Plansearch Inc. (under contract) taking into consideration the hydrogeological characteristics of the site.

The community survey consisted of the administration of a questionnaire to a 15% random sample of households selected from each area - WS, EG and Tec. Blood samples were collected from all members five years of age and over in a sub-sample of the selected households. In areas A and B surrounding the landfill site a higher proportion of households were included in the questionnaire and blood samples. (All households for A were included for interview and half of these households for blood samples. Twenty percent of the households for B were included for interview and half of these households for blood samples.) The questionnaire was constructed using tested instruments such as the Canada Health Survey, and pretested in Ottawa. Verification of self-reported, significant health conditions was carried out (7.1% of the interview sample) through private physician and hospital records.

The sample response for the WS, EG, and Tec areas were comparable as evidenced by the similarity in sociodemographic and lifestyle characteristics; the response rates were similar (85%). Adjustment for the usually confounding variables such as age, sex, and socioeconomic status was generally unnecessary in this study because these variables were comparable in all study areas. All comparisons were adjusted for period of residence and length of residency and no substantial differences were noted in the results. Within WS, WS-A (the sub-area of WS having the highest potential risk of contaminated drinking water) had proportionately more long-term residents than WS-B and WS-C.

RESULTS:

The outcomes studied in this report were selected for their potential association with exposure to the WS landfill site and to potentially contaminated drinking water resulting therefrom.

WS, EG, and Tec had a comparable prevalence of survey reported long-term (chronic) illnesses for the years 1965 to 1985. Patterns were similar in the WS-A, B, and C areas as well.

Small survey reported cancer rate differences were seen in WS, EG, and Tec, though these differences were not statistically significant. Breast cancer had a higher reported rate in WS than EG or Tec. When the specific areas were cross-checked with medical records, all of the survey reported cases could not be verified and up to 10% over-reporting may have occurred.

Survey reported outcomes of pregnancy, congenital anomalies, and birthweights showed similar patterns for WS, EG, and Tec. There was a slight but not statistically significant increase in the self-reported cases of spontaneous abortions in WS. Most of the defects reported were not major and have not been thought to be associated with chemical contamination. Birth defects which have been linked to specific etiologies such as Down Syndrome and neural tube defects were of a very low incidence or did not occur at all.

The population-based (Congenital Anomalies Surveillance System) perinatal mortality rates were higher during 1975-79 for WS, but were similar for WS, EG, and Tec during 1980-84. Five-year cumulative rates were used from 1975 to 1984 because of the small number of cases per year.

The overall distribution of values for hemoglobin, hematocrit, liver enzymes (alanine transaminase, aspartate transaminase, alkaline phosphatase), white blood cell count, blood film examination and total cholesterol did not differ between areas and sub-areas.

Population database-generated all cause mortality, all cancer mortality, and lung and breast cancer mortality did not reveal statistically significant differences among WS and the comparison areas. Breast cancer mortality rate in WS for the period 1974-1978 was slightly but not statistically significantly higher than EG and Tec. These mortality rates were lower than Ontario and Canada in all areas examined.

Registry-based incidence data for all cancers, lung cancer and breast cancer showed an increased rate for WS compared to EG and Tec; the rates in WS were lower than the rates in the Regional Municipality of York (containing WS and EG) and Simcoe County (containing Tec). One possible explanation for the discrepancy in rates for EG and Tec compared to their region/county is underreporting due to missing residency codes.

CONCLUSION:

In conclusion, there is little or no evidence that the residents of WS are experiencing adverse health outcomes attributable to the proximity of their residence to the (now inoperational) WS landfill site and a possible exposure to chemical contamination in their drinking water.

RECOMMENDATIONS:

Based on the results of the study survey and the examination of population registry-data from routine sources, and considering the concerns of the residents of WS, the following recommendations are made:

1. Since the results of the survey and population-based mortality and morbidity statistics show:

    - no severe short-term health conditions;
    - no significant increase in the prevalence of most chronic (long-term) illnesses; and,
    - no significant increase in the prevalence of adverse reproductive outcomes;

    and since the landfill site is no longer operational, therefore, **no further follow-up survey of health outcomes is necessary** for the WS area; and,

2. Since the source of contamination is now closed, it is unlikely that similar concerns would arise in the future. Most of the health problems arising from the landfill site, other than possibly some long latency cancers, should already have appeared. The only cancer which showed any significant increase in WS compared to EG and Tec was breast cancer. However, breast cancer has not been associated with drinking water contamination and, furthermore, the rates of breast cancer incidence and mortality were comparable or lower in WS than the provincial average, and all three areas (WS, EG, and Tec) showed a decreasing trend over the last ten years. The monitoring of population mortality and morbidity registry information can be used to detect and identify any possible future trends in health outcomes. In the unlikely event that the chemicals deposited in the site flow out and contaminate the water supply gradually, the monitoring of the water table around the landfill site by the Ministry of the Environment should serve as a warning sign to identify (future) possible contamination of drinking water. Therefore, it is recommended that **no further study of health outcomes be carried out to determine future health problems resulting from the possible contamination of drinking water.**

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1.0 INTRODUCTION

The residents of the Town of Whitchurch-Stouffville (WS), north-east of Metropolitan Toronto, have expressed serious concern about adverse health outcomes possibly due to contaminated drinking water resulting from a local landfill site. The WS landfill site, operated between 1962 and 1985, had been used for the disposal of domestic and industrial waste. Primarily, as a result of hazardous, industrial waste disposal during the late 1960's and early 1970's, there was local concern that chemicals might be leaching from the site and contaminating drinking water in the area.

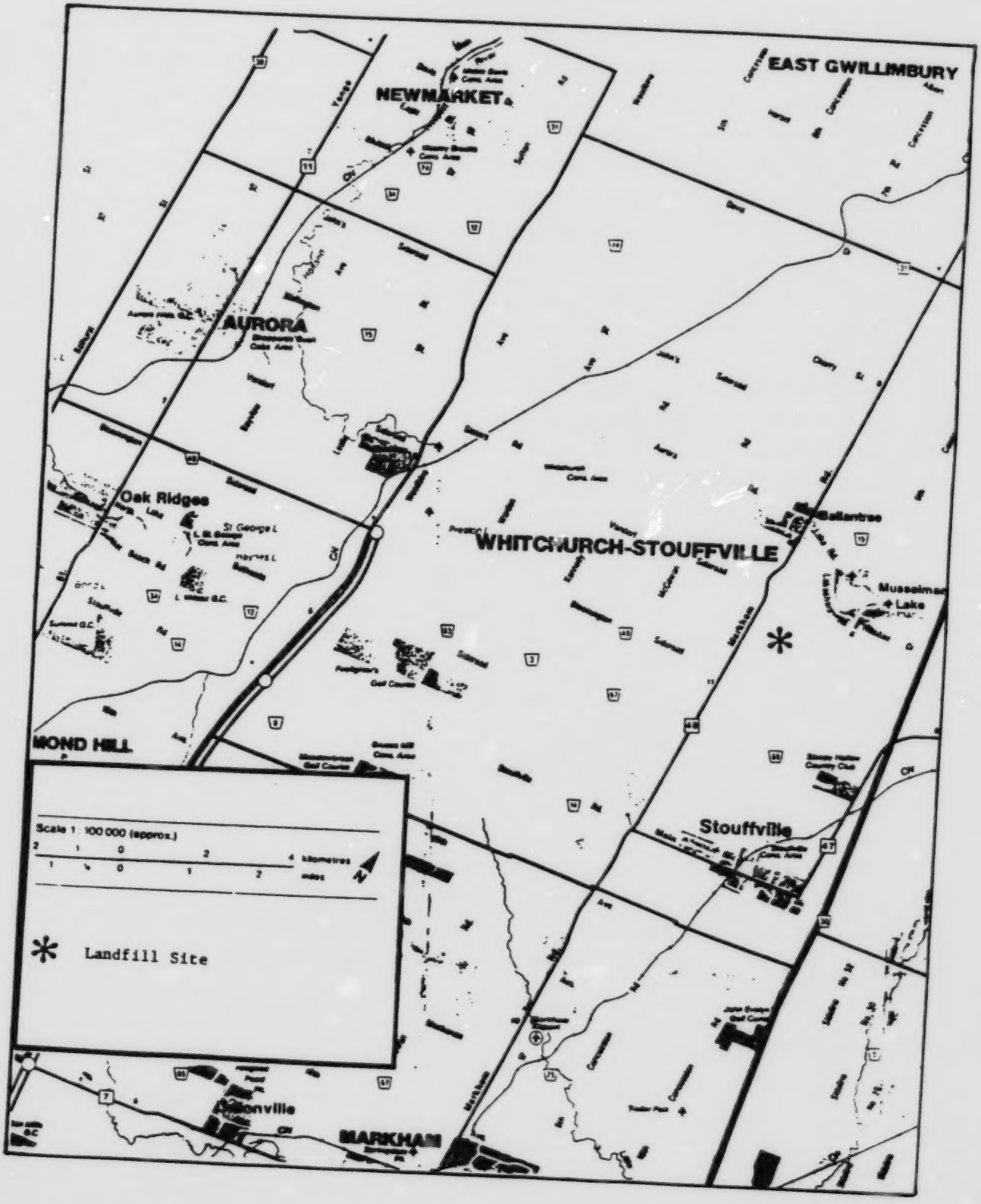
The Ontario Ministry of Health, in collaboration with the Medical Officer of Health in the Regional Municipality of York and the WS Citizens Advisory Group, undertook a community health study of the area. The study was carried out under contract to Goss, Gilroy & Associates Ltd.

This report documents the results of the health study, and as such, provides details on all facets of the study. In this introductory section, background information on the landfill site is presented together with a summary of the study's literature review.

1.1 BACKGROUND

The location of the WS landfill site in relation to the Whitchurch-Stouffville area is shown in Figure 1.1. The area is approximately 16 km north-east of Toronto, and just north of Markham and east of Richmond Hill. The WS landfill site is frequently referred to as the Stouffville Landfill Site, and is more formally known as the York Sanitation No. 4 Landfill Site, and previously, as the Brenner Waste Disposal Site. In this report, the site is referred to as the WS landfill site.

FIGURE 1.1: WHITCHURCH-STOUFFVILLE AREA



The WS landfill site began operation in 1962 with the disposal of domestic wastes. From 1965 to its closing in June, 1985, a variety of industrial and domestic waste was dumped at the site. It is known that liquid industrial wastes were disposed into six natural depressions at the site during the mid-to-late 1960's. These depressions were located on both sides of the site's main access road and are now known as lagoons L1 to L6.

In November 1969, the Ontario Water Resources Commission banned liquid waste disposal at the site and, though the ban was removed in January 1970, apparently no additional liquid wastes were accepted at the site. In May 1970, the Whitchurch Township Council passed a By-law banning liquid waste disposal, effective June 15, 1970.

After the banning of liquid waste disposal, the lagoons were subsequently filled with solid waste, graded and capped with till to reduce the infiltration of precipitation. Most of the open lagoons were filled and capped by early 1974, although work on L1 was not completed until 1976. By 1976, thousands of routine tests had been conducted by the Ministry of Environment on well water quality in areas adjacent to the site. The overall conclusion was that although the well water tests proved satisfactory, the wastes constituted a potential serious pollution problem if they leached into ground water or surface water.

No accurate documentation of waste disposal for the years before 1974 is available, but from May 1976, to the closing in June 1985, quarterly reports were prepared which documented waste disposal operations and the removal of cover material from soil borrow areas. A review of the key geology, hydrogeology, water chemistry and quality is presented in a Hydrogeological Report of the WS area by MacLaren Plansearch Inc., appended here as Appendix D.

In 1981, efforts by the owners of the landfill site to extend the site peaked a long history of public concern. A submission to the WS Town Council in March 1981, by a citizens' group stated that "... there is undesirable evidence that the site has been leaking heavy metals and the avenues of egress are being followed by toxic chemical waste such as chlorinated hydrocarbon for which there is no safe threshold. Plume action from this unsecured dump, places the town's water supply at risk and as a consequence, the health of its citizens both young and old". This submission was also submitted to the Medical Officer of Health for the Regional Municipality of York and to the Minister of Health. Further citizen involvement included surveys of self-reported pregnancy outcomes and cancer incidence for individuals living in the vicinity of the landfill site. These results were submitted to the Medical Officer of Health and to the Provincial Ministers of Health and Environment. In essence, the concerns of the residents focussed on contamination of drinking water. It must be noted however, that the citizens' group surveys were conducted by a special interest group during a very sensitive period of the site's history, and there were no comparison/control areas to validate their findings.

From May to June, 1981, Environmental Assessment Board Hearings were held in Stouffville in response to the site owner's application to extend the site. Although the request was refused, the site was allowed to continue operating under a Provisional Certificate of approval with the requirement that additional groundwater monitoring should be carried out. During the subsequent two to three years, extensive testing of groundwater quality was carried out on water from monitoring holes on site and from closely located domestic wells. The Stouffville municipal wells, located two kilometres to the south, were also tested. In February, 1983, the Environmental Appeal Board issued a Provisional Certificate of Approval for the site which stipulated that waste disposal should cease by June 30, 1985. The site was closed as scheduled in June, 1985.

In parallel with the foregoing, in January 1982, the Ontario Ministry of Health contracted the Department of Community Medicine and Epidemiology of Queen's University to determine the feasibility of undertaking a comprehensive scientific study of the health of the residents of WS. The Queen's report concluded that a meaningful epidemiological study of health problems was feasible. Terms of reference for a full epidemiologic study were developed by the Ministry of Health, the Medical Officer of Health in the Regional Municipality of York and the WS Citizens Advisory Group. Members of the Group were: Dr. John Hodgkinson, Associate Medical Officer of Health for the Regional Municipality of York, and Chairman of the Group; Mrs. Fran Sainsbury, Mayor of Whitchurch-Stouffville; Mr. James Sanders, Councillor of Whitchurch-Stouffville; Mrs. Anne Gagnon and Mrs. Debi Mitchell of the Concerned Citizens of Whitchurch-Stouffville; and Dr. J. Owen Slingerland, Commissioner of Health and Social Services, and Medical Officer of Health for the Regional Municipality of York. The study was carried out under contract to Goss, Gilroy & Associates Ltd., a management and statistical consulting firm based in Ottawa.

1.2 LITERATURE REVIEW[1]

As a consequence of what is considered useful activities, the industrial society produces a variety of domestic and industrial wastes. These wastes, which in some cases have toxic qualities, are most commonly disposed of in landfill sites. The Whitchurch-Stouffville (WS) landfill site is an illustration of a site that has received both domestic and liquid industrial chemical wastes.

In general, over the past decade, research has shown that such disposal sites vary widely in the nature of their geology, hydrology, ecology, physical and chemical composition. Although there is a high level of

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[1] A glossary of terms is provided in Appendix G to assist the reader in the intended interpretation of "common" jargon or technical terminology necessarily used throughout the report.

public concern over the potential hazards of chemical waste disposal, relatively few chemical disposal sites have been studied rigorously. For chemical disposal sites where epidemiological studies of exposed populations have been undertaken, results are often equivocal[1]. There has yet to be established a definitive causal link between organic chemical hazardous waste sites and adverse health effects. Moreover, there is no convincing evidence that the sites are innocuous (R6 - Reference 6 in section 10). There are no well-documented examples of low-level environmental exposures to man-made chemicals resulting in a demonstrable higher incidence of cancer[2].

This lack of scientific data is not surprising, given the many technical difficulties inherent in exposure measurement and establishing a cause and effect relationship to health outcomes. However, these investigations cannot be interpreted to indicate that no risk exists but rather, that no serious health effects clearly attributable to the sites have been detected to date by the study methods employed[3].

Nonetheless, we have found it useful to draw upon the information contained in the excellent review article by Buffler, Crane and Key (R1; 1985), who summarize most of the pertinent, current occupational and environmental literature on populations exposed to chemicals from waste disposal sites. They present a number of useful research guidelines and study design signposts that relate to the WS Health Study as follows:

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[1] Excerpt from "Health aspects of hazardous waste disposal", Environment, Vol. 28, No. 3, April (1986) p.38-41.

[2] Excerpt from "Compensation of victims exposed to environmental pollutants", Archives of Environmental Health, Vol. 41, No. 3 (1986) p.185-189.

[3] Excerpt from "Health aspects of hazardous waste disposal", Environment, Vol. 28, No. 3, April (1986) p.38-41.

- as a general rule, potential human exposure levels around abandoned waste sites may be much lower than around active sites, unless persistent chemicals are involved; (R1; p.424)

- the use of contaminated aquifers for drinking water by populations quite remote from the waste disposal site could result in a much larger population exposed but with a lower probability of detecting any adverse health outcomes because of the extremely low doses received; (R1; p.424)

- the predominant health effects reported in these low exposure situations are more likely to be nonspecific (neuro-behavioural, reproductive, hepatic, renal); (R1; p.450)

- the severity and immediacy of responses are dose-related and are directly related to route of exposure; (R1; p.450)

- episodes in which food was directly or indirectly contaminated resulted in the most severe response; (R1; p.450)

- short-term, very low exposures are far less likely to induce any of the health effects identified, whereas chronic exposures of any intensity and acute high exposures may induce a wide range of effects; (R1; p.425)

- population exposures resulting from chemical waste disposal sites are usually much lower than those observed in work environments or accidental environmental exposures; (R1; p.425)

- skin and central nervous system conditions were judged to be the most likely effects from direct contact with chemicals; (R1; p.425)

- hepatic, hematopoietic, renal, reproductive and central nervous system effects were considered to be the most likely indicators of chronic low-dose exposure by way of ingestion; (R1; p.426)

- both central nervous system and reproductive disorders appeared likely to occur in a number of exposure circumstances, both high and low dose, and also from a variety of chemical agents; and, (R1; p.426)

- lung, gastrointestinal and cardiovascular disorders, although important in occupational exposures, were considered unlikely in low dose exposure situations such as would occur around a toxic waste disposal site. (R1; p.426)

It is emphasized that these foregoing statements represent broad, explicit **hypothetical** research propositions by the authors, based on their review of current studies in the occupational and environmental health literature. The authors note that no attempt was made to evaluate critically the quality of evidence reviewed for each health effect. Our purpose for using such review information was strictly to clarify research issues related to this health study and for some assistance in formulating better operational definitions of morbidity variables for the survey-component of the study.

Information complementary to the foregoing guidelines on the health effects of long-term consumption of contaminated well water are contained in the Levine et al. review paper (**R6**; 1985), and the Lagakos et al. paper (**R5**; 1986). The latter paper highlights the recent Woburn, Massachusetts study, and, selected comments by a reviewer are noted below:

- there have been few studies to date that have shown a relationship between neighbourhood exposure to toxic chemicals and diseases in the residents; for example, from the Love Canal study, of the various diseases attributed to living near the Love Canal in the late 1970's, only low birth weight has achieved some kind of acceptance. A well-publicized study of cytogenetic abnormalities was unable to be confirmed, although the group sampled in the second study was somewhat different from the first; furthermore, cancer incidence studies in the Love Canal have thus far been negative (**R4**; 1981), but insufficient time has elapsed to observe increases in cancers with long latency; and,

- the Woburn study is one of the few that has convincingly shown some disturbance in health of the neighbourhood residents in relation to exposure to water contamination. Positive statistical associations were found between access to this water and the incidence rates of childhood leukemia, perinatal deaths, and some categories of congenital anomalies and childhood disorders; no associations were found with spontaneous abortions, low birth weight, or the other categories of congenital anomalies and childhood disorders.

Smith and Victor (R10, R11; 1986) discuss various health aspects of environmental contamination in the Niagara and comparison region, and analyze specifically those effects related to reproductive outcomes and drinking water contamination. The following comments are taken from their papers:

- many epidemiologic studies have demonstrated various patterns of associations between certain risk factors and congenital anomalies, with each anomaly having a distinct pattern, whether simple or complex;
- among these risk factors are maternal age, maternal and paternal occupation, ethnic origin, socio-economic factors, as well as drug and other chemical exposure; for example, association between maternal age and Down syndrome, and maternal/paternal occupation and maternal life style and genetic history with other anomalies have been documented;
- although there are a number of chemicals and therapeutic agents which have been demonstrated as human teratogens, there is not much evidence at this time that congenital anomalies have increased with the increased exposure to low concentrations of chemicals as found in the general environment;
- nonetheless, the examination of birth defect patterns in relation to general environmental factors can guide the subsequent exploration of other hypotheses and examination of other risk factors which may be operating in a specific population; and,
- studies using population-based registries are necessarily limited to observational and correlational analyses. Direct cause and effect relationships between environmental events and measures of health in a population cannot be established by routine surveillance through these systems alone. However, these data bases can be used to demonstrate areas of concern if there is consistency in the type of adverse outcome, or if an outcome is sustained over time. If these criteria are met, interventions may be developed or further research can be conducted.

With respect to the history of drinking water quality in Whitchurch-Stouffville, a number of Ministry of the Environment (MOE) reports are listed in section 10 (i.e., R7; R8; R9; R10); these reports summarize several detailed investigations by the MOE over the last decade.

Analytic results of monitoring of private wells since 1966 and on site wells since 1970 are published in the 1983 MOE report (R7). Regular quarterly monitoring has been conducted by the MOE since 1976 as a condition of approval for the landfill site. The Ministry's monitoring confirmed that:

- the landfill site has not affected the potability (safety and drinking quality) of any private wells;
- the landfill site has not affected the two municipal wells in Stouffville;
- there is no evidence that PCB's (i.e., organic contaminants) have migrated from the dump site; and,
- local contamination in four domestic wells is unrelated to the dump site and is due to other sources. Two wells are known to be contaminated by road salt and one has a high bacterial count.

The MOE investigations concluded that there was no mutagenic activity in the six private wells tested. Industrial chemicals detected in the dump site could not be linked with low, trace levels of organics in the off-site wells.

2.0 PURPOSE OF THE STUDY

The overall purpose of the study is twofold:

- to establish whether the WS residents are experiencing adverse health effects from fugitive contamination of drinking water resulting from the WS waste disposal site; and,

- to establish if there are measurable risks of future adverse outcomes as a result of current exposure.

The study was designed to determine if the residents of WS experience or have experienced adverse health effects with a higher frequency than the residents of two comparison communities matched for sociodemographic characteristics, but unexposed to industrial waste disposal sites. In addition, the study was designed to test the hypothesis that residential proximity to the landfill site is associated with adverse health outcomes.

An overview and assessment of the geology, hydrogeology, and water chemistry of the WS area, and a detailed review of the history of the WS disposal site from this perspective was undertaken by Dr. David L. Charlesworth of MacLaren Plansearch Inc. The MacLaren report is enclosed as Appendix D. This work was an integral part of the study design (see section 3.0 for details). It provided an exposure risk model based on the potential for contamination of the water table in areas around the landfill.

2.1 SPECIFIC RESEARCH OBJECTIVES AND HYPOTHESES

The specific research objectives of the study are presented in terms of the following research questions:

(1) what is the total mortality in WS? does it differ from that of the comparison areas selected for the study?

(2) what are the leading diagnosis-specific causes of death in the WS population compared to the selected comparison areas and compared to the Province of Ontario as a whole?

(3) what are the leading age- and sex-specific causes of death in the WS population compared to the selected comparison areas and the Province of Ontario as a whole?

(4) how does the incidence or prevalence of each health indicator in the WS study population compare to the incidence/prevalence in the selected comparison areas and with the incidence/prevalence in the population of the Province of Ontario as a whole? Health indicators are: short-term health problems; long-term health problems; disability (bed/hospital) days; physician visits; cancer incidence; and adverse reproductive outcomes.

(5) is there a dose-response gradient of frequency of adverse health effects within WS related to proximity of residence to the landfill site?

(6) is there a gradient with respect to length of residence in WS?

(7) is there a difference in adverse health effects which can be ascribed to drinking water source?

(8) do levels of physiologic variables or biomarkers as measured in a sub-sample of the study population show patterns that are coherent with the findings on health outcome variables? do the physiologic findings add construct validity to the findings ascertained about the health indicators? are abnormal physiologic measurements (hemoglobin, hematocrit, etc.) more prevalent among the sample of WS residents compared to those of the selected comparison areas?

(9) do measurements ascertained for physiologic biomarkers correlate with exposure indices (e.g., proximity to the landfill site, length of residence, source of drinking water) such that all findings are buttressed by construct validity.

The foregoing research questions can be expressed in scientific terms as statistical null hypotheses as follows:

1. There is no difference in total mortality rates within major areas (proximity to site) within WS, nor between WS and the selected comparison areas, and the Province of Ontario as a whole.

2. There is no difference in leading diagnosis-specific mortality rates within/between ... (as in 1).

3. There is no difference in leading age and sex-specific mortality rates within/between ... (as in 1).

4. There is no difference in the incidence and prevalence of specific and non-specific health indicators within major areas, (proximity to site) within WS, between WS and the selected comparison areas.

5. Same as #4 above, adding: ...controlling for confounders such as age, sex, etc.

6. There is no difference in physiological measurements (i.e., blood tests) within/between ... (as in 4) controlling for confounders such as age, sex, etc.

7. There is no correlation or interactive effect of: proximity to landfill site, length of residence and source of drinking water on physiologic biomarkers and all health indicators.

3.0 STUDY DESIGN

This section describes the study design of the community health study of WS residents: the survey of residents (3.1) and the collection of mortality and morbidity statistics (3.2). The section concludes with the pertinent highlights of the ethical considerations and rationale for this design (3.3).

A cross-sectional survey design of a random sample of WS, EG and Tec residents was used to assess self-reported short and long duration health effects, especially cancer and reproductive outcomes.

A historical trend analysis of registry-based data on cancer mortality, all cause mortality, reproductive outcomes, and cancer incidence was also undertaken.

Consideration was given to a range of possible confounding factors (age, sex, socio-economic status, lifestyle habits, drinking water consumption pattern and perceptions) throughout all analyses.

3.1 SURVEY OF RESIDENTS

In addressing the purposes of the study (section 2.0) from a statistical design perspective, any observation or conclusion related to adverse health effects due to contaminated water or otherwise, needs to be examined against an appropriate comparable "control" area(s). This then allows the observations to be assessed against "random variations" in health effects noticeable in a population. This perspective leads naturally to the decision of how best to select the comparative control areas, which is discussed below.

3.1.1 Selection of Comparison Areas

The selection of appropriate comparison (or control) areas is one of the most crucial steps in any epidemiologic study. In a cross-sectional survey (such as the present study), where one area exposed to environmental contamination is examined in detail, a control area has to be identified which is similar in as many respects as possible to the study area, except for the exposure of interest. Using 1981 census data, two communities were chosen for comparison with WS. These were selected on the basis of socio-demographic best-match, and for proximity to WS. (Section 10; reference 11: Murdie report; a complete copy of the Murdie report is attached as part of Appendix F of this report.) Each of these had a small landfill site: the size and makeup are listed below.

The study area (WS) is the Town of Whitchurch-Stouffville, where a commercial waste disposal site was in operation for a period of twenty-four years (1962-1985). The type and quantity of chemicals dumped at the site, the observed run-off from this site, and perception that people living near the site were experiencing unusual rates of health problems raised the concerns of local citizens. Possible contamination of drinking water by the site sparked the development of the present study.

The Town of Whitchurch-Stouffville (WS) is primarily a farm community situated northeast of Toronto. Most of the population of WS is concentrated in the town of Stouffville in the southeast corner of the township. The age, income and other socio-demographic characteristics of the population are described elsewhere in this report (section 6.0).

The Town of East Gwillimbury (EG), situated to the north of, and adjacent to WS, is a similar township. It consists primarily of a farm community and two major population areas of similar socio-demographic makeup as WS.

EG also has a chemical waste disposal site similar to WS, but differs significantly in two ways:

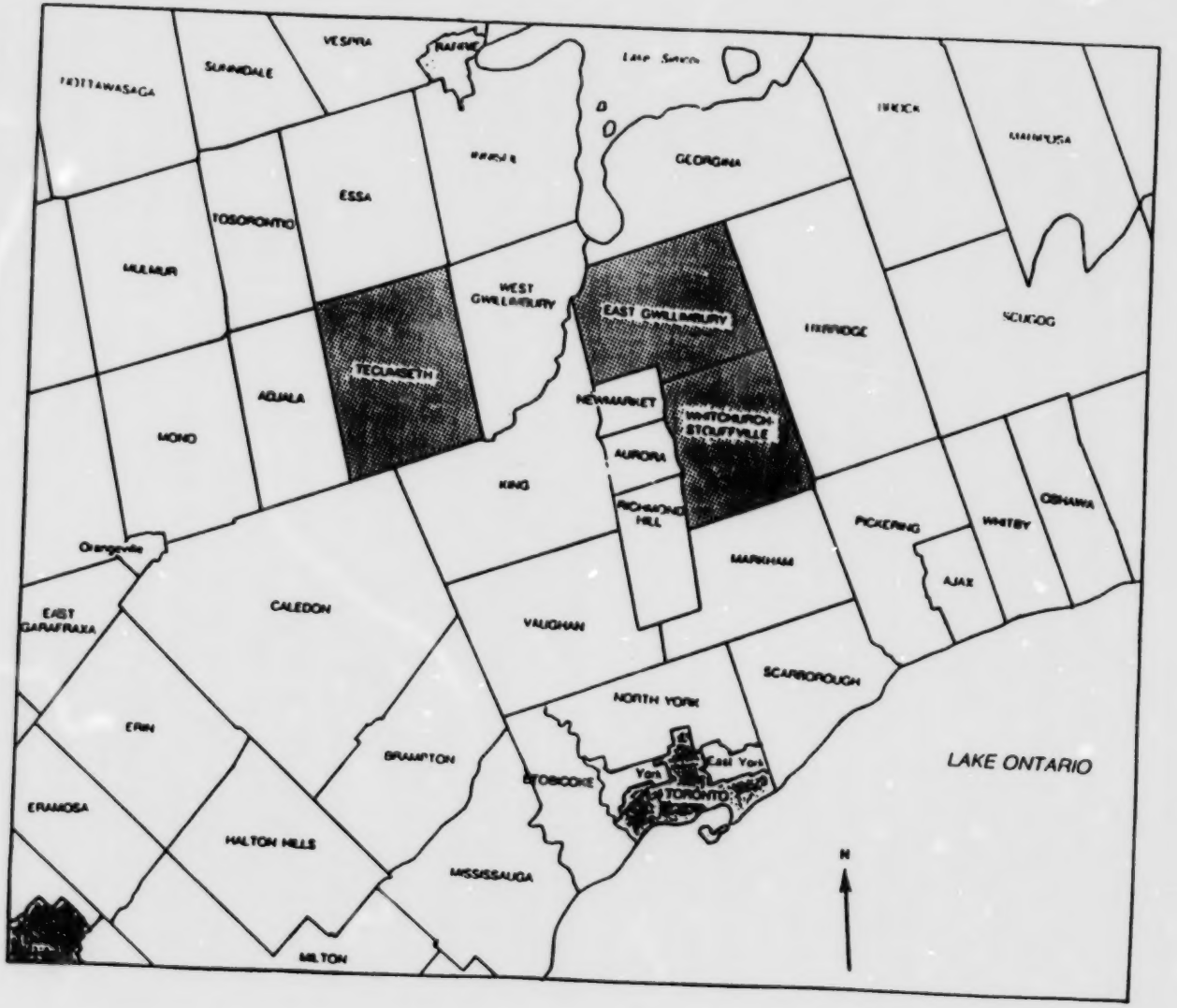
(i) the size: the quantity of chemicals dumped at the site is much smaller (i.e., average annual volume of waste disposed at this site is about 15% of the equivalent figures for the WS disposal site when it was in operation); and,

(ii) the compositional make-up: the EG waste is much different (i.e., the EG waste does not contain any of the heavy metal chemical waste deposited at the WS site).

Nevertheless, the presence of this disposal site is of concern for any comparison of health effects. For example, if there was no observed difference between EG and WS, one would not be able to say with any confidence that the waste disposal/landfill site in WS did not lead to any adverse health outcomes. EG will, therefore, serve as a control area having a disposal site of smaller size. The EG control area, by serving as an intermediate exposure area, permits a crude estimate of dose-effect relationship to be used in the study design and analysis.

The Township of Tecumseth (Tec), which includes the towns of Tottenham and Beeton is the closest sociodemographic match where there is no major waste disposal site (i.e., annual volume of waste disposal at the Tec site is less than 1 percent of the previous volume figures for the WS site). MacLaren Plansearch evaluated the volume and composition of the chemicals dumped at the Tec site and the potential for these to end up in the water supply of the township. They concluded that there is a minimal amount of waste disposal at the site, and that the nature of the groundwater movement from beneath the site and the absence of down-gradient users is such that the site posed negligible or no risk to any local residents. Therefore, Tecumseth was chosen as a second control area. Figure 3.1.1 presents the geographical overview of the three health study communities.

FIGURE 3.1.1: HEALTH STUDY COMMUNITIES



Proximity of the control area to the WS study area was another logistical consideration; however, this consideration was secondary to the aforementioned criterion of similarity to WS and relative presence or absence of waste disposal sites.

Acceptance by the residents to voluntarily participate in a health study was also important. Acceptance of the study by EG residents was documented in the feasibility study; no information was available prior to the start of the study as to the acceptability and willingness of the Tec residents to participate in such a comprehensive health study. Appendix E discusses the data collection, implementation and quality assurance methods used in this regard.

3.1.2 Sample Determination

From the outset of the study, as described in the terms of reference, a number of salient facts helped formulate the subsequent survey strategies and sample determination:

(i) the WS landfill site had a long and varied history of disposal activity from 1962 to 1985, giving rise to different exposure periods (e.g., up to 1970, and after 1970; Appendix D: MacLaren report);

(ii) the landfill site was known to contain mixtures of chemicals, primarily organic chemicals, and concern was centred on leachate from the site entering the surrounding groundwater which was used for drinking water;

(iii) given that the hypothesized major route of exposure was ingestion, the study designated exposure groups by using surrogate exposure variables. Surrogate exposure to fugitive emissions was indirectly estimated by length of residence, period of residence (pre-1965, 1965-69, 1970-74, 1975-79, 1980 on), as well as proximity to the landfill; and,

(iv) the design considered a range of confounding variables (age, sex, socio-economic status, lifestyles, drinking water habits and perceptions).

A large random sample of residents of WS, EG and Tec was selected to address the overall study objectives and the hypotheses given in section 2.0. This is referred to as Design Level I, or main area comparisons. In addition, a sufficiently large sample of residents in the WS areas of highest potential exposure to contamination from the groundwater system was selected in order to examine exposure gradient effects in the local area due to fugitive emissions to water. This is referred to as Design Level II, or sub-area comparisons.

The sample size for each design level was calculated to meet the power* and statistical significance* criteria set out a priori. A power of 80% and a statistical significance level of 5% were used for each of the main areas (WS, EG, and Tec). Because costs were a consideration and blinding of interviewers to the residence status of respondents was important, telephone rather than personal interviews were conducted. The choice of the telephone interview allowed us to increase the sample size by 30% within the allotted cost, thereby considerably decreasing problems due to small sample sizes. This had the added benefit of increasing the statistical power to 90%. Based on previous studies and on advice from the Technical Advisory Group, it was expected that the marginal decrease in response rate expected from the telephone survey would be more than compensated by the advantages of larger overall sample sizes with its concomitant increased power.

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* Sample size calculations were based on the probability of failing to detect a true difference (of 10% or more) in frequency of effect between the areas where one exists (Power 80%, Beta 20%) and on the probability of declaring a difference where none exists (Alpha 5%, Confidence 95%).

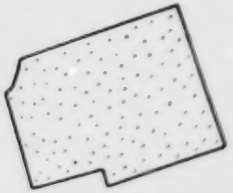
Point estimates for means, percentages, and rates, along with their respective standard errors or confidence interval estimates formed the basis for comparisons between the study areas.

Finally, the design strategy included a rigorous set of procedures and controls at every major stage in the execution of the study in order to ensure the quality of the data. Appendix E highlights the key methods and how the process of quality control was implemented.

Design Level-I - Simple Random Sample of Main Areas (WS, EG, and Tec): Figure 3.1.2 presents a summary of the study design and sample size allocations. That is, the household and target sample allocations (interview questionnaire and blood samples) are summarized, along with the number of people in residential institutions, for the three main Study areas (WS, EG, and Tec). A two-stage sampling procedure was employed for the three areas. The primary sampling consisted of a simple random sampling of all the households identified by the sampling frame. All residents from a selected household were included in the second stage sampling, giving a sampling fraction of 100% for the second stage.

Names and addresses were obtained from the Ontario property assessment database (Fall, 1985) with the assistance of the Ministry of Revenue. Eligible households were defined according to detailed sample frame specifications provided to the Ministry of Revenue. Subsequently, a household was strictly defined (according to the Canada Health Survey criteria) as any group of persons living together as one "family-unit" (typically, sharing common bathroom and kitchen facilities). Simple random sample selection procedures were applied to the Ministry's listing to prepare the target sample size lists (including a randomly-selected list of replacements or substitutions - see Appendix G: "Replacement Sampling" for further details). A computer-based random number generator was used for this selection.

FIGURE 3.1.2: DESIGN LEVEL-I - STUDY DESIGN AND SAMPLE SIZE (SIMPLE RANDOM SAMPLE)

	WHITCHURCH-STOUFFVILLE		EAST GWILLIMBURY		TECUMSETH	
• denotes random samples for main areas of Study						
POPULATION (based on 1985 Ministry of Revenue Assessment Data)						
# of HOUSEHOLDS	4,608		4,193		3,534	
# of PEOPLE	14,934		14,032		11,952	
TARGET SAMPLE (Excluding Institutions)	Interview Questionnaire	Blood Samples	Interview Questionnaire	Blood Samples	Interview Questionnaire	Blood Samples
# of HOUSEHOLDS	650	100	600	100	550	100
# of PEOPLE	2106	300	2010	300	1859	300
% (TARGET SAMPLE) / (POPULATION (PEOPLE)) (Excluding Institutions)	14.1%	2.0%	14.3%	2.1%	15.6%	2.5%
(Excluding Institutions)	TOTAL TARGET SAMPLE (PEOPLE): 5,975 % OF COMBINED POPULATIONS (PEOPLE): 14.6%					
INSTITUTIONS						
# PEOPLE IN POPULATION	156	N/A	145	N/A	158	N/A
# PEOPLE IN TARGET SAMPLE	25	N/A	25	N/A	25	N/A
% (TARGET SAMPLE) / (POPULATION (PEOPLE)) (Including Institutions)	14.1%	N/A	14.4%	N/A	15.6%	N/A
(Including Institutions)	TOTAL TARGET SAMPLE (PEOPLE): 6,050 % OF COMBINED POPULATIONS (PEOPLE): 14.6%					

N/A = not applicable; see text for details.

In total, 1800 households (having 5975 people) were randomly selected for interviews from the three areas: 650 households from WS (2106 people); 600 households from EG (2010 people); and, 550 households from Tec (1859 people). This target sample represented about 15% of the respective populations of each area. An 80% response rate was the a priori acceptable level of survey success for the statistical power and confidence settings to be achieved and to have negligible rates of non-sampling errors (see section 5.0 and Appendix E).

A separate sampling frame was used to sample residents from institutions, such as nursing homes, homes for the aged and rest homes. (There were no hospitals in the three areas.) Since a telephone interview with residents in institutions was impractical, a personal interview was used to collect the necessary information. It was assumed that in the case of an institutional resident, a household consisted of one person. Based on information from local officials, the total number of eligible residents in institutions in each study area was quite similar: WS - 156; EG - 145; Tec - 158. Twenty-five persons per area were chosen as the target sample size; this choice still maintained the sampling fraction for residents of approximately 15%.

It was anticipated that some residents **not** in institutions would require a personal rather than telephone interview due to various reasons - e.g., unlisted or unknown telephone number; no telephone; privacy considerations such as party lines; and, other personal reasons. It was expected that any potential interviewer bias could be minimized by the application of rigorous training and field procedures (Appendix E), that the relative magnitude of in-home interviews would be small, and that comparable proportions of telephone to personal interviews would occur across the three main study areas.

Blood samples were taken from a sub-sample of all survey participants. Everyone within selected households excluding children under five years of age were requested to give a blood specimen. The inclusion of children five years of age or older was an important part of the blood

testing program. Since children's blood assays are more sensitive to chemical changes or shifts than adults, they may provide valuable indicators of environmental exposures. Residents in institutions were excluded from the blood sampling phase because of the difficulty in obtaining consent to draw blood from aged populations and the general unreliability of subsequent results given the lack of information on confounding variables such as medication use and other medical conditions.

The target sampling fraction for blood was initially set at 2.5% (or 1 in 40 eligible persons). This gave 108 target households in WS, 100 in EG, and 92 in Tec. For administrative convenience a revised sample size of 100 households was used for all three areas.

From the outset, it seemed likely that a household might agree to be interviewed but refuse consent for blood sampling. To overcome this, the blood sampling design considered the following: if the response rate fell below 50%, a further sample of the remaining households (i.e., the ones not identified for blood sampling initially) would be identified randomly and approached for blood sampling. If the original household refused the interview itself and was also a household selected for blood sampling, then any randomly selected replacement household automatically became selected for blood sampling.

The collection and analysis of blood specimens were contracted out to MDS Laboratories of Toronto. The coordination of this phase with the study team is described in Appendix E.

Design Level II - Sample of Sub-Areas of WS (using Model for Potential Exposure to Contamination): A hydrogeologically-based model for the WS area was developed based on several criteria outlined in the MacLaren report. MacLaren Plansearch's role in the study was to review the geology and hydrogeology of the area around the landfill site and, on the basis of groundwater flow patterns, develop an exposure model which would serve as a basis for determining a sampling frame and probability model

for this study. For example, a higher sampling density would be used in those areas (or zones) where the potential exposure to contaminants was greatest and lower sampling density in areas with less risk of exposure to contaminants. In summary, the model criteria involved looking at flow directions in the shallow and deep groundwater systems and at the results of the chemical sampling carried out over the years in the vicinity of the landfill in particular, and in WS in general.

Figure 3.1.3 presents the sub-areas identified by the above model and Figure 3.1.4 presents the summary of the design and sample size allocations for these sub-areas.

The sub-area WS-A (also called Zone A) was defined as "that area within which the residents would have had the greatest potential exposure to contaminants which might have moved off the site by transport in the groundwater system". The sub-area WS-B (Zone B) was defined as "an intermediate area, larger than but not containing Zone A, established within which wells might have been exposed to contaminants in the unlikely event that the hydrogeological model arising out of the extensive studies at this site should, in fact, be seriously in error". For the rest of the Study, area WS-B was defined as those parts of original area B but excluding area A. Thus, the A and B areas as referred to in the study (WS-A, WS-B) are mutually exclusive (non-overlapping) with respect to each other. WS-A represents the area most likely at risk of exposure to groundwater contamination, and WS-B the next most probable area at risk.

For convenience of referencing in the report, sub-area (or Zone) A will be referred to as "the area with the highest potential exposure", and sub-area (or Zone) B as "the intermediate potential exposure area". Note that the remainder of WS (excluding WS-A and B), denoted WS-C, then represents the "negligible" risk zone of WS based on the MacLaren model. As will be seen (sections 5.0 and 6.0), sub-area WS-C will be employed as

FIGURE 3.1.3: POTENTIAL EXPOSURE ZONES FROM WS LANDFILL SITE (MACLAREN REPORT; PAGE 3-6)

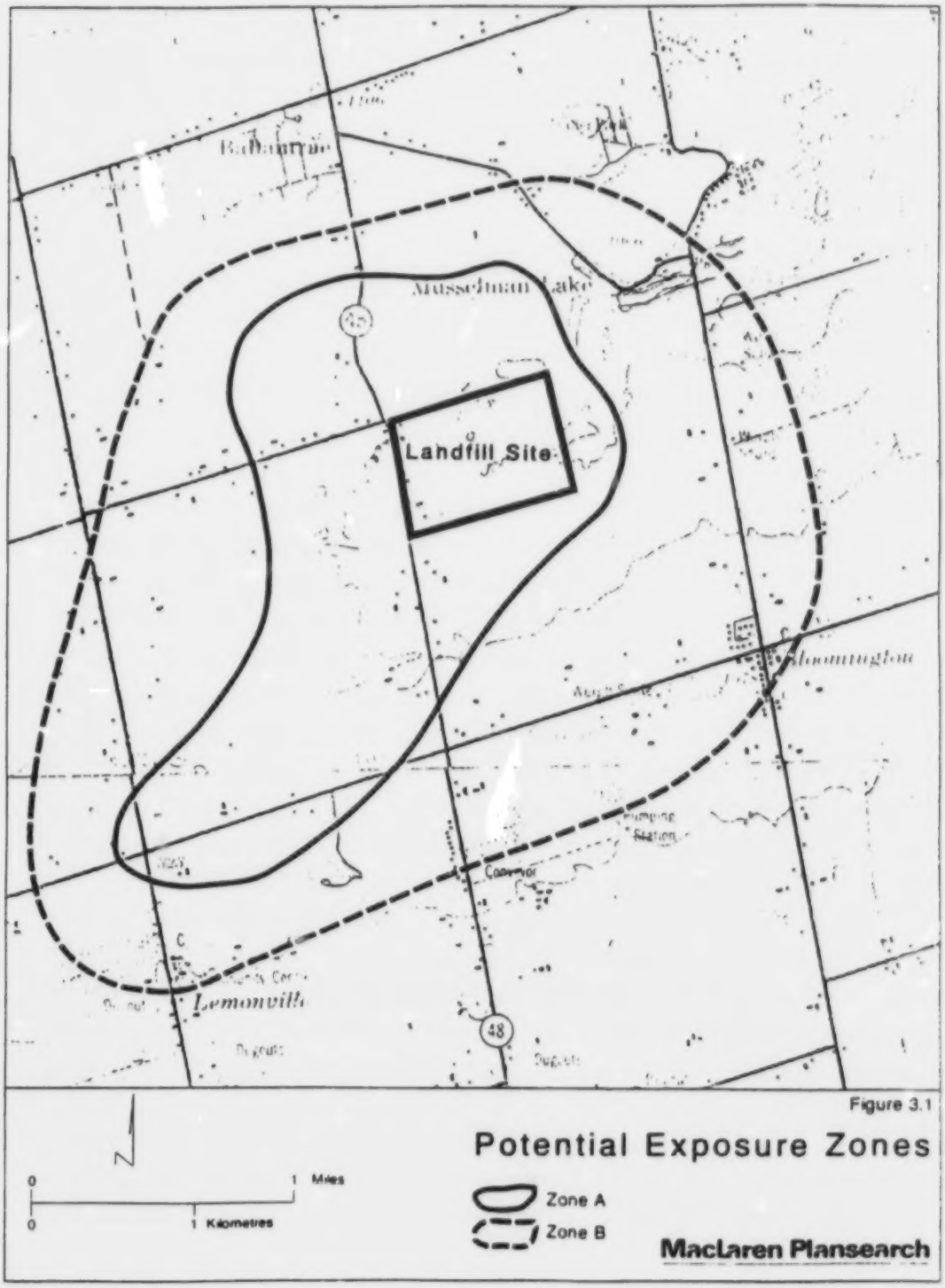
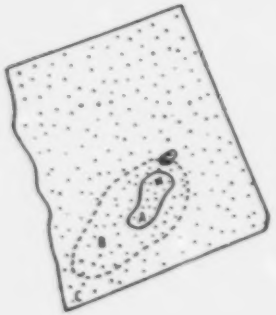


FIGURE 3.1.4: DESIGN LEVEL-II - STUDY DESIGN AND SAMPLE SIZE (CENSUS OF A, SIMPLE RANDOM SAMPLES OF B AND C)

WHITCHURCH-STOUFFVILLE TOWNSHIP



NOT TO SCALE - FOR ILLUSTRATION ONLY

LEGEND

- denotes (random) samples for sub-areas of WS
- denotes dumpsite
- denotes Musselman Lake
- denotes designated areas, mutually exclusive sub-areas within WS where increased samples will be drawn; contours represent potential exposure zones assuming hydrogeological model of local ground water system is accurate (zone A), or inaccurate (zone B) (See MacLaren Report referenced in text and in Appendix for details)

POPULATION*	WS-A		WS-B	
# of HOUSEHOLDS	38		354	
# of PEOPLE	125		1,158	
TARGET SAMPLE (Excluding Institutions)	Interview Questionnaire	Blood Samples	Interview Questionnaire	Blood Samples
# of HOUSEHOLDS	38	20	62	30
# of PEOPLE	125	61	190	92
Σ (TARGET SAMPLE)/(POPULATION (PEOPLE)) (Excluding Institutions)	100%	49%	16%	8%
INSTITUTIONS				
# PEOPLE IN POPULATION	N/A	N/A	94	N/A
# PEOPLE IN TARGET SAMPLE	N/A	N/A	15	N/A
Σ (TARGET SAMPLE)/(POPULATION (PEOPLE)) (Including Institutions)	100%	N/A	16%	N/A

* Based on 1985 Ministry of Revenue Assessment Data.
N/A = not applicable; see text for details.

the "internal control" zone within WS, with which the survey results will be directly compared against the results of sub-areas WS-A and WS-B. Designations of (WS) sub-areas WS-A, WS-B, and WS-C also provide an indirect measure of "proximity to the landfill site".

The population residing in close proximity to the landfill site (WS-A) is small. A random selection of residents from all of WS was not likely to select a sufficiently high number of "high exposure" residents, thus possibly underestimating an excess of adverse health complaints from this area. To avoid this problem, a census of all residents in WS-A was targetted. Similarly, a more intense sampling of WS-B (sampling rate of 20%) was also targetted.

From the 1985 Ministry of Revenue assessment data and with the assistance of local officials in assembling institutional data on resident populations, the following sampling plan was employed:

(i) for WS-A, all eligible households (and people) were included in the sample coverage (i.e., 100% or census coverage);

(ii) for WS-B, 20% of the households (i.e., about 1 in 5 persons) were randomly selected (using the same methods as described above) for inclusion in the survey; and,

(iii) for WS-C, the sampling units (households) and sampling fraction were the same as given in Design Level-I above (i.e., 15% sampling rate). Design Level-I samples of selected households from sub-areas A or B were excluded.

The total target sample size for sub-areas A and B combined was rounded to 100 for convenience. The complete (100%) coverage of A (38 households) was maintained, while the revised target coverage for B was 62 households. Given that some of these households would be included in the original random sample (Design Level-I), it was expected that an additional (to Design Level-I) 55 to 75 households (150-250 people) for these two areas would have to be interviewed.

Based on costing, logistics, and statistical power for the blood sampling program, a 50% sample was chosen for the target sample sizes of the WS sub-areas A and B. This provided a total target blood sample of 50 additional households (about 150 persons), distributed between sub-area A (20 households) and B (30 households). Straightforward procedures were used for handling duplicate samples arising from the two Design approach. Design Level-I was always treated as the primary comparison where maximum sampling was sought throughout the collection phase. Blood samples were excluded for the residents in institutions. Replacement households for blood samples were identified in advance. Operating instructions guided all aspects of replacement sampling and are discussed in section 6.0 and Appendix G.

3.2 MORTALITY AND MORBIDITY STATISTICS

In addition to the survey data, population data were obtained from three agencies: the Ontario Cancer Treatment and Research Foundation (OCTRF), the Congenital Anomalies Surveillance System (CASS), and Statistics Canada. These data are useful in complementing the information collected by the survey, and are a more precise tool for investigating trends over time. Precise trend data cannot be obtained from a general survey approach because of (recall) biases, non-response, mobility, etc. Since the agency information is based on complete population data, sampling error is not an issue. Due to the confidentiality requirements of the agencies, only summary statistics are presented*.

Congenital anomalies and pregnancy outcome data were obtained from CASS. This system is based primarily on the Hospital Medical Records Institute (HMRI) data in Ontario, which represents about 95% of all births in Ontario. Birth defect data were obtained for the period 1975-1984 from this source. Data prior to 1975 were not of sufficiently high quality to be useful and therefore were not made available. In addition, data at the level of sub-areas were not available.

In both mortality and morbidity data, 5-year cumulative statistics were used to compare the three study areas (WS,EG,Tec) as well as WS with Ontario and Canada. Trends were examined by displaying 5-year cumulative rates over time. Similar information was not available for WS-A, B, and C.

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* When the actual number of events is low for an area, individuals could theoretically be identified by the reader and confidentiality breached.

3.3 ETHICAL CONSIDERATIONS

All aspects of the study which involved the direct participation of the study subjects were carefully addressed with respect to concerns about confidentiality of information (e.g., personal interview responses; medical records data; etc.) and other ethical considerations. For example, careful attention was given to those areas of study which involved the measurement of physiological variables (i.e., individual blood sampling), so as to protect all study subjects from intrusion or assault or harm. The study team designers placed considerable importance in choosing team personnel with extensive experience in health surveys which included physical measures in order to ensure that these concerns were respected. Appendix A illustrates how this was accomplished.

The detailed study package (purpose/objectives; approach methodologies; instruments; consent forms; blood testing procedures; etc.) was submitted to a formal Ethics Committee for review prior to implementation. The Ottawa Civic Hospital Ethics Committee, chaired by Dr. R. Saginur, carried out this review. The study was given full approval by the Ethics Committee. On a particular note of their review, other useful and complementary blood assays were suggested (without increasing the amount of planned, required blood specimens) to augment the initial blood testing coverage. These helpful suggestions were followed in the final design of the blood testing program. Copies of the Study's consent forms (Appendix B) and other relevant documents (Appendix F - blood testing results form; medical record review form; consent-related letters to physicians or hospital administrators; etc.) are attached herein. The specific MDS Laboratory blood testing procedures (field protocols), lab analysis methods, storage/transport protocols, and quality control monitoring documentation (see sections 4.2.3, 5.4 and Appendix E) are available upon request from the project director of the study.

4.0 OUTCOMES OF EXPOSURE AND OBSERVATIONS ON HEALTH STATUS

This section highlights the key sources of data and data items to be collected to address the study objectives and research questions.

4.1 EXPOSURE SURROGATES OF POSSIBLE WATER CONTAMINATION

A number of possible water contaminants at or near the WS landfill site are listed in the MacLaren report (Appendix D; Table 2.2). Some of the same chemicals have been reported in the literature as being linked with adverse health effects and contamination of water supplies (see R1; section 10). Specifically, these are:

Chemical (in Water Supply)	Reported Health Effect (in Literature)
Arsenic	- Skin cancer; Blackfoot disease (a disorder of peripheral circulation); various cutaneous lesions affecting the skin
Lead	- Hematological and peripheral nervous system effects
Phenol	- Diarrhea; mouth sores; dark urine; burning in the mouth
Cadmium	- Bone pain; proteinuria; glucosuria
Mixture of organics and metal, especially arsenic	- Childhood leukemia; perinatal death; birth defects
P.C.B.	- Liver problems; high blood pressure.

Such information on exposure surrogates of possible water contamination aided the study team in the clarification of and focus on specific research issues and data items to be collected. It also provided "checklist guidelines" for ensuring that a thorough study design and data analysis plan was implemented.

4.2 HEALTH STATUS

A cross-sectional comparative design was used to address the study objectives and hypotheses. Health status was assessed from four perspectives:

(i) at the individual-level

- personal interviews with residents using an interviewer-administered health questionnaire;
- medical diagnoses as reported on medical records of a sample of respondents (section 4.2.2):
- measurement of physiologic markers (blood analysis) from a sample of respondents (section 4.2.3); and,

(ii) at the population-level

- profiles for mortality and morbidity (cancer; reproductive outcomes) from registry-based information (section 4.2.4).

4.2.1 Health Questionnaire

A health survey questionnaire (see Appendix C) was designed and developed to provide information on short-term and long-term health conditions and reproductive outcomes experienced by respondents. Questions related to environmental exposure such as length of residence in township, drinking water source, and potential confounding factors such as sociodemographic profile, lifestyle, family history, and health risk perception. The questionnaire was mainly constructed using tested survey instruments for each required group of study variables to be measured. Table 4.2.1 presents an overview of the health survey questionnaire, showing the twelve major sections (modules) of the questionnaire and where they were obtained.

TABLE 4.2.1: OVERVIEW OF HEALTH SURVEY INTERVIEW QUESTIONNAIRE - MAJOR SECTIONS BY PRIMARY SOURCE

QUESTIONNAIRE SECTION	CONTENTS	PRIMARY SOURCE*
I.	Demographic Information	PC, GGA
II.	Activity Status	CHS
III.	General Health Status - Short-Term	CHS
IV.	Pregnancy Outcomes	WHS
V.	General Health Status - Long-Term	CHS
VI.	Doctor and Hospital Visits	CHS
VII.	Deaths in Household	GGA
VIII.	Occupation and Working Environment	Niagara, CHS
IX.	Lifestyles - Smoking, Alcohol, - Physical Activity	GGA, Niagara CHS
X.	Drinking Water and Health	GGA, Niagara
XI.	Education	Niagara
XII.	Family Income	Niagara

* LEGEND:

GGA - Goss, Gilroy & Associates
CHS - Canada Health Survey, conducted 1978-1979
Niagara - Cancer and its Risks Community Health Survey, May/June 1985
WHS - Women's Health Survey (never conducted)
PC - Pottersburg Creek, London, Ontario; PCB Exposure
Toronto - Community Health Survey, 1983

The final questionnaire encompasses questions which arose from:

(i) the terms of reference of the study, which were a joint effort involving the Ministry of Health and the local WS Citizens Advisory Group chaired by the Associate Medical Officer of Health for the Regional Municipality of York (see Appendix A for the study organization chart);

(ii) the literature review (section 1.2) and the MacLaren report (section 4.1);

(iii) various meetings with local officials, individuals, and groups in the three areas, particularly the WS general public meeting; and,

(iv) ongoing advice and direction from the project team's Advisory Committees (Appendix A).

The questionnaire addresses measures of health in the population as follows:

- **Morbidity** - self-reported, short-term (acute) and long-term (chronic) health problems, including all reproductive outcomes;

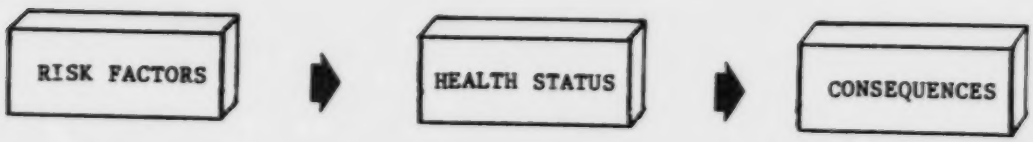
  - clinically-diagnosed problems (chronic) and adverse reproductive outcomes;

- **Mortality** - members of families who died since the family lived in the township;

- **Consequences of Morbidity** - physician/hospital services;
  - activity limitation;

- **Risks** - environmental risks: drinking water quality related to proximity to disposal site; occupation and work environment;
  - family history;
  - self-imposed risks: lifestyle habits (alcohol, smoking, exercise); and,
  - perceived health risks of chemicals in drinking water.

The Canada Health Survey Interviewer-Administered Questionnaire[1], along with its underlying design, development and implementation rationale, formed the basic framework for integrating and implementing the various sections (modules) of the Study questionnaire. This basic framework uses the simple risk factors/health status/consequences model[1] for integrating various health concepts and attributes:



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[1] The Canada Health Study is profiled in the report The Health of Canadians, published by Supply and Services Canada, June (1981; 237 pages). Also, see the complementary background report A New Perspective on the Health of Canadians, Lalonde, M., Government of Canada report, Ottawa (1974) 76 pages.

Each group of data to be collected is identified and categorized within this framework; Figure 4.2.2 provides a summary of the data items to be collected*. As this general health model is commonly used to assess the overall health status of individuals, for the WS study, in particular, it hypothesizes that the potential burden of ill-health attributable to the physical environment would be reflected in a measurable excess in the frequency and duration of short-term and long-term health problems, and of various measures of activity limitations (e.g., loss of work). Note that the detailed questions concerning reproductive outcomes independently contributes to this "health status profiling". The questionnaire, therefore, used measures of time-based disability outcome as a primary indication of health status. For example, if any one of the 34 questions on chronic conditions was affirmatively responded to, then four additional questions were generated - covering the start year and current status of the condition, and whether or not treatment for the condition is currently being followed. Up to 8 unique problems could be probed in this manner for each family member.

Health care utilization as measured by the frequency, duration and reason for physician or hospital visits, was used as a behavioural indicator of the severity of reported health problems. Medical record follow-ups of the more serious reported problems (typically chronic problems and adverse reproductive outcomes) provided additional detail and/or medical ascertainment of the reported information. Blood samples provided an explicit measurement of physical health on a number of blood parameters.

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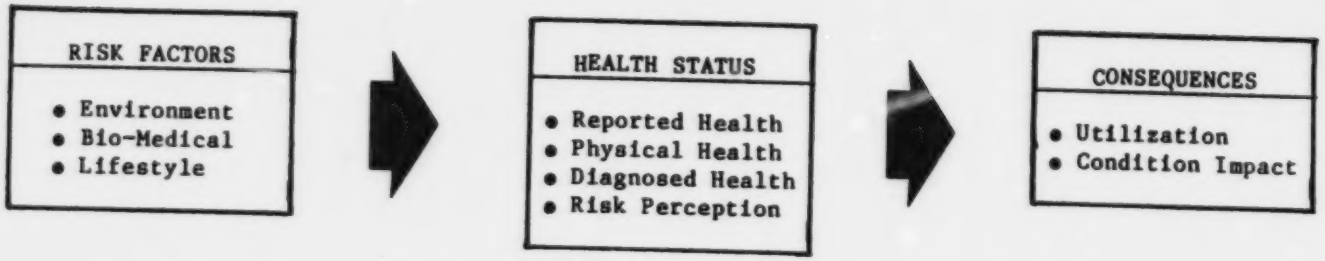
* For additional details, see The Health of Canadians, Supply and Services Canada, June (1981; 237 pages).

FIGURE 4.2.2: WS HEALTH STUDY – SUMMARY OF DATA ITEMS TO BE COLLECTED BY BASIS CATEGORIES OF INFORMATION

MODEL



DATA

Environment

- exposure to chemical mixtures (MacLaren proximity-to-site risk model)
- mortality and morbidity statistics

Bio-Medical

- cholesterol
- other blood assays
- family disease history

Lifestyle

- alcohol use
- tobacco use
- physical activities

Reported Health

- activity limitations
- short-term conditions
- chronic conditions
- impairments
- reproductive outcomes

Physical Health

- blood assays (e.g., liver function)

Diagnosed Health

- clinical diagnosis (chronic conditions; adverse pregnancy outcomes)

Risk Perception

- chemicals in drinking water

Utilization

- physician visits
- hospital visits
- reasons care not sought

Condition Impact

- disability

Demographic Characteristics

- social characteristics
- economic characteristics
- mobility, immigration
- life events

A series of questions in the section on Drinking Water and Health allowed measurement of a response within each geographic area, in order to assess the level of awareness of potential problems associated with chemicals in drinking water and the respondent's perception of personal health problems.

4.2.2 Medical Records

The study design incorporated the follow-up of reported health problems at physicians' offices and with hospital medical files. This phase of project activity was called Medical Records Review (MRR).

For each respondent to the study's Health Questionnaire, a standard set of screening criteria for MRR, determined a priori by the study team, were applied by team nurses to either "accept or reject" each respondent for the review. All survey respondents were included in the screening exercise. In general, eligible (MRR) respondents had reported either a long-term health problem and/or an adverse reproductive outcome.

The purpose of the reviews was three-fold: to ascertain the reported health condition, and to collect more information on the stated or other clinical diagnosis, and to identify health problems in the physician's files but not reported by the respondent in the survey. Thus, for the sub-population of residents reporting the more serious health conditions or adverse reproductive outcomes, estimates of agreement/disagreement rates (for both over- and under-reporting) were obtained. The standard MRR form used by the field team, along with the introductory protocol letters, are attached as an exhibit in Appendix F.

4.2.3 Blood Analysis

Households randomly selected from the large sample of respondents were requested to participate in the donation of a small blood specimen. This aspect of the study allowed direct measurement of several biomarkers in the population.

The blood tests included: hemoglobin, hematocrit, white cell count, blood film examination, platelet count, red cell morphology, white cell morphology, total cholesterol, alkaline phosphatase, alanine transaminase and aspartate transaminase. Both categorical (abnormal, normal; low, normal, high) and continuous variables were formed and analyzed for most of the biomarker measurements. All non-institutionalized residents, including children at least five years of age, were included in the sample. Due to the lack of diagnostic reliability of the cholesterol measurements in children, only those respondents 16 years of age or older had a cholesterol analysis.

A licensed technician from MDS Laboratories visited each selected and consenting household to take the required blood specimen(s) from all eligible household members. MDS Laboratories and study team site supervisors coordinated all blood sampling activities, lab analysis, and assembly of blood sample data. The standard lab reporting form is exhibited in Appendix F. The appropriate consent forms for adults and children are given in Appendix B. Details on the blood lab testing and analysis procedures, the storage and transport of blood, and the protocols for follow-ups of elevated blood results are given in Appendix E.

4.2.4 Mortality and Morbidity Statistics

All mortality data were obtained from Statistics Canada. These data represent census population figures for all the survey areas of the study, in addition to Ontario as a whole. Mortality by age, year of death and cause of death (ICD codes)* were tabulated for the period 1971-1983 for the study areas and Ontario as a whole, as well as for Canada.

Morbidity data were collected from two sources:

(i) congenital anomalies data for the period 1975-1984 using the Congenital Anomalies Surveillance System (CASS), which collects information from several sources including hospital separations supplied by the Hospital Medical Records Institute (HMRI), including the number of livebirths, stillbirths, spontaneous and therapeutic abortions, perinatal and early neonatal deaths, Down syndrome, spina bifida, anencephalus, and hydrocephaly; and,

(ii) cancer incidence data for the period 1979-1983 provided by the Ontario Cancer Treatment and Research Foundation (OCTRF), including age-standardized data for all cancers and specific cancer types (female breast, male lung) at the township, county, and province level.

Appendix E contains further details on the collection activities used for these population-based registry statistics.

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* ICD: International Classification of Disease Coding Manual (see Appendix G).

5.0 ANALYTIC METHODS

This section highlights the data analytic methods and rationale used in the study. Important data limitations and quality control measures underlying some of the methods or subsequent collection activities are described here.

5.1 GENERAL APPROACH

Categorical data were tabulated for frequency distribution across the three study areas using the SPSS-X package at the University of Ottawa's computer facilities. For continuous data, means and standard errors of means were computed. Each individual hypothesis was tested using the chi-square test for proportions or the t-test for means. Initially, demographic and socio-economic characteristics of the areas were compared; for factors that had different distributions in the three areas, adjustment using the indirect method of standardization was done to obtain age-standardized rates.

Design Level-I comparison of the three areas: WS, EG, and Tec, was relatively straightforward since the three samples were simple random samples from the respective populations, using the household as the primary sampling unit. Design Level-II comparison between sub-areas WS-A and WS-B was also similarly straightforward; comparison of samples from WS-A or WS-B with WS-C is not a statistically independent comparison. However, due to the relatively large sample sizes in WS-C compared to WS-A and WS-B, any resultant bias due to statistical dependence would be minimal and we chose to ignore this bias.

5.2 DATA LIMITATIONS

5.2.1 Survey

All sample surveys give rise to two types of error: error due to sampling (denoted **sampling** error); and, error due to non-sampling biases and variabilities, such as those associated with measurement, ascertainment, non-response, processing, etc. (denoted **non-sampling** error). The sampling error was estimated using standard sample survey techniques (section 10; reference 3). With the large sample sizes in our study the sampling errors for most variables are quite small; where the incidence or prevalence is extremely small, the relative sampling error could be high. When comparing between WS-A, B, and C, the different sampling fractions were taken into account in computing the sampling errors.

The magnitude of the non-sampling errors are characterized primarily by the level of survey non-response, given that the utmost detail and methodological rigour were applied to all areas of potential sources of non-sampling error (i.e., to ensure a minimal effect on the resulting data). With about 84-85% response rate in all three areas, it was not considered necessary to estimate this error by standard procedures (e.g., by taking sub-samples of the non-respondents and collecting some basic demographic and other information). Moreover, since the current field methodology had employed a thorough approach to obtain cooperation from respondents, including conducting personal interviews where the respondents refused or could not take part in telephone interviews, we did not feel we would gain much by trying to document non-response bias. In addition, the three study areas had similar response rates and had similar socio-demographic characteristics between them. Each sampled population area also had similar socio-demographic characteristics compared to the parent population. In total, these observations therefore suggest that non-response bias, if present, is very small.

Other potential sources of non-sampling error would consist of measurement error (i.e., bias due to recall, interviewers, etc.), processing error, sampling frame/design bias, and/or migration bias. Every effort was made to eliminate these sources or at least, have as small chance of the error as possible. The frame used for the three areas was the same (i.e., the provincial assessment rolls). Since the three areas were from the same province, it is unlikely that a selection bias due to the sampling frame could arise. In the analysis, equal weights were given for the three areas since the study was designed to obtain the same sampling fraction. However, the achieved sampling fraction was slightly different for the areas. Again, this was not considered to be a major concern, since the resulting sample sizes are quite large and the sample distribution of demographic variables was quite similar to the population distribution. Another possible problem, due to the two-stage sampling design, might be the different household size distributions in the three areas. Analysis of family sizes would provide for detecting and adjusting for this potential bias. Also, because the second stage sampling fraction was 100%, any clustering of health problems within households could be a potential source of bias. Again, analysis of health problems within families would detect and remove any such bias. On the other hand, the two-stage sample design procedure provided for logistic simplicity without affecting the statistical power except in very limited cases. There was a concern that more outmigration might be occurring in WS due to the perception of possible exposure to the landfill site. However, the distribution of length of residency (see section 6.0) suggests that this is not the case. The only way to address this potential migration bias would be to do a residential cohort study*. The costs of this type of study would be very high, and other confounding variables would have to be adjusted for in assessing the relationship of landfill exposure to outcome.

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* This type of study was scoped out of the Terms of Reference of the present study for various reasons (see following text).

As noted above, another possible non-sampling error is recall bias. While there is no fool-proof way of determining if recall bias was present, the empirical results supports our view that this bias, if any, is minimal. Three reasons for this conclusion are: (i) the medical records review showed similar rates of 'over' and/or 'under'-reporting of cases for all main areas and sub-areas of the study; (ii) the reported rate of spontaneous abortions (which is perhaps the adverse outcome most susceptible to recall bias) showed similar patterns; and, (iii) the overall reported rates were similar to national and provincial rates where such information was available for comparison.

Most of the questions in the questionnaire were chosen from previously used, validated instruments. However, recall bias is possible in many questions, in particular, considering the long period of 20 years for some of the long-term conditions and pregnancy outcomes. However, since the same technique was used across the three areas, it is expected that any measurement error attributed to the instrument alone would be similar, and thus, would not affect the area comparisons. Interviewer bias could exist, for example, if the probing by the interviewer was affected by their knowledge of the target study area and the past publicity of potential water contamination in the area. In order to minimize this source of error, a blind (telephone) interview technique was used for most of the data collection following the standard approach for such studies (see Appendix E for details).

The collected data were screened and edited by the supervisors at the site. During the coding stage, all key data fields were screened again and re-edited. After the first tabulation of the data, additional checking for data inconsistencies was carried out and any discrepancies investigated and corrected.

Thus, we are quite confident that the effect of non-sampling errors on the study results is minimal. Selective recall for people from WS is a possibility. Consistency of results with population (registry) data (for those variables where these were available), and with other objective measures, suggests that the survey procedures were able to overcome biases if they were present.

Partial response bias exists in that for some individuals or households, some questions were answered while others were not. The magnitude of partial response varied by major section of the questionnaire, ranging between 0% and 8% of all sampled cases. Reasons for partial refusals varied widely. Typically, the cause was a particularly sensitive circumstance of the respondent such as a recent baby death in the family or financial information considered very private. We have dealt with this type of error by simply including only those with information, for any given question. We could have used various statistical modelling techniques of imputation to "estimate" or model these missing values, but in the absence of any way to verify the authenticity, we chose to ignore the missing values and simply assume that they were on the average of a similar distribution as the observed responses.

Another limitation of the study design is the choice of a cross-sectional survey. Most of the problems of cross-sectional surveys (e.g., the problem of migration) have already been discussed. The cross-sectional survey provides a "snap shot" in time and thus does not provide valid estimates of risk to an exposure. To circumvent this problem, persons in the observed sample were questioned on "past history" to develop a retrospectively constituted cohort. This leads to the other common problem, that of recall bias, which has also been discussed. Considering the cost of the study and the fact that the landfill site (i.e., the source of "exposure") is no longer operational, a cross-sectional survey was the best available design.

5.2.2 Blood Results

Population sample errors are higher for the blood results because of the smaller sample size included in the blood analysis. Non-sampling errors are similar to the ones already discussed for the survey. Additional non-sampling errors may occur if the method of analyzing blood has errors. These errors are relatively small and well documented by the Laboratory. Inter-laboratory error would not be applicable in comparisons between the study populations since the same laboratory was used for analyzing blood specimens taken from the main study areas and the WS sub-areas. It should also be noted that the laboratory contracted

to perform this work has its own quality control, monitoring and reporting system for assessing the quality of the blood analysis done by each technician.

5.2.3 Mortality

All mortality data were obtained from Statistics Canada. These represent total population figures. However, accuracy of these data depend on the completeness and accuracy of the reporting system. The three main study areas were identified by the appropriate census sub-divisions. Mortality data are not available at finer levels of disaggregation (e.g., WS sub-areas) from the Statistics Canada database as these areas do not correspond to the smallest sub-division census tract.

5.2.4 Morbidity

Data from CASS were obtained in tabular form. CASS data are compiled primarily from the Hospital Medical Records Institute (HMRI) data and corroborated with other sources of data. Normally, the HMRI could include multiple admissions, but reproductive outcomes data are aggregated to single cases.

Cancer incidence data were obtained from OCTRF. The data were reported as of very good quality at the county (region) level and for the metropolitan areas. At the township level, there is a possibility of underreporting because residency codes may be missing. Thus, a cancer is ascribed to the county but may not be identifiable with a township. The degree of missing residency codes could vary from 10% to 70% depending on the geographic area (OCTRF: personal communication). It is not easy to estimate the effect of this error in WS, EG, and Tec. However, the incidence rate of cancer in WS is similar to the Region to which it belongs (York). EG and Tec cancer incidence rates are lower than their respective region or county (York and Simcoe). This may suggest that the missing residency code may not be a serious problem in WS compared to EG and Tec, or, alternatively, that EG and Tec have much lower cancer incidence rates than the rest of its surrounding areas.

5.3 DATA ANALYSIS

5.3.1 Questionnaire

The questionnaire included 78 primary and 50 secondary questions on demographic information, general health status and pregnancy outcomes, physician and hospital visits, deaths in the household, pattern of drinking water use, occupation and working environment, socio-economic status and awareness of problems with drinking water and its relationship to health.

The demographic data (age, sex, length of residency in dwelling/township, household size) and socio-economic status (occupation, education, family income) were used to compare WS, EG, and Tec for similarities in background and possible confounding variables. Adjustment for the confounding factor was done using this information.

Pattern of use of drinking water and awareness of problems with drinking water and health were analyzed separately to compare the three main areas, and to identify if any of these potential confounding variables could explain any observed difference in health parameters between the three areas.

Even if the results were not different statistically, any difference greater than 10% in any self-reported event between WS and EG and Tec, or between the sub-areas of WS, was closely examined. A case-by-case analysis, including confirmation with a Medical Records Review was carried out.

The results are displayed in graphical and tabular format. Standard errors of rates were plotted or included in tables where applicable.

5.3.2 Medical Records

Medical record verification was not as complete as originally planned due to the Physicians' strike in Ontario which occurred near the end of the field collection interviews, effectively blocking access to many medical records. The results of the available verification records were examined for consistency of health problems, as reported by the surveyed population and as recorded in the appropriate physician/hospital records. Agreement between a reported health problem and the physician or hospital record was reported and analyzed by professional nursing staff hired for this particular collection task. The medical record audit was also used in individual situations where detailed analysis of health problems was necessary to examine some differences in rates and where possible over-reporting was suspected.

5.3.3 Blood Samples

All results of analysis of blood were tabulated by sex, age, area of residence, length of residence, and proximity of residence (in WS) to the landfill site. Sub-areas A,B, and C were used as proxies for distance from the landfill site. The following parameters were examined: hemoglobin, hematocrit, white cell count, blood film examination, platelet count, red cell morphology, white cell morphology, total cholesterol, alkaline phosphatase, alanine transaminase, and aspartate transaminase.

5.3.4 Mortality

The number of deaths for the three main study areas, as well as for Ontario and Canada, were obtained from Statistics Canada for the years 1971-1983. The data were classified by age at death, cause of death, and calendar year of death. Deaths due to all causes, all cancers, specific cancers and infant deaths were examined for statistically significant differences between the three main areas, and between WS and Ontario and

Canada. Some specific cancers, for example, cancer of the breast in females, were examined because of suspected differences as detected from OCTRF data. Trends in mortality rates by the year-groups 1971-73, 1974-78, and 1979-83 were compared for the three areas. The population base for each of the groups was the appropriate census year data. That is, 1971-73 (74-78)(79-83) used the 1971 (76)(81) census populations for the appropriate area. The death rates were age-standardized using the indirect method with the 1981 census population of Canada as the standard.

5.3.5 Hospital Separation

Hospital separation rates from CASS were obtained for the following causes: livebirths, stillbirths, perinatal deaths, spontaneous abortion, and birth defects (anencephaly, Down syndrome, spina bifida, hydrocephaly, cleft palate/lip, esophageal atresia, rectal atresia, hypospadias, reduction deformity of limbs, and congenital dislocation of hip). The rates for the three study areas as well as their respective region or county (York: WS, EG; and, Simcoe: Tec) were plotted for the period 1975-84. Because of the small number of events in each calendar year, five-year cumulative rates were compiled and two 5-year periods (1975-79 and 1980-84) were compared. Because even the five-year cumulative rates were extremely low, cleft palate/lip, esophageal atresia, rectal atresia, recuction abnormality, hypospadias, and congenital dislocation of hip are not displayed.

5.3.6 Cancer Incidence

Cancer incidence data for the three main areas and the Regional Municipality of York and Simcoe County were obtained from the OCTRF. Due to the confidentiality requirements at OCTRF, we were able to obtain only the standardized, incidence rates (and standard errors) for: all cancers; cancer of lung for males; and, cancer of breast for females for one time period (1979-83). Contexted by the cautionary remarks regarding the cancer registry coding problems (noted in section 5.2.4), these incidence data were compared for the one five-year period provided.

5.4 QUALITY CONTROL

Collection and compilation of data incorporated rigorous quality control measures. Development of sampling frame, sample design, questionnaire design and pretest as well as drawing of samples were done under the supervision of the principal investigators (Goss, Nair, Turnbull) and discussed with the Technical Advisory Committee. During the survey, every effort was made to increase the response rate and minimize non-response or partial response errors.

Interviewers were trained and their performance periodically monitored and data verified. Questions and problems that arose during the interview phase were resolved by the principal investigators. Collected data were verified before entering into the computer as well as after the first tabulations.

Registry statistics were collected from agencies experienced with the production and use of these databases and their expertise was relied upon for quality. Validation checks were made on tabulated data to verify confirmation with published data.

Details of these quality control activities are given in Appendix E.

6.0 RESULTS

6.1 SURVEY RESULTS

6.1.1 Survey Response

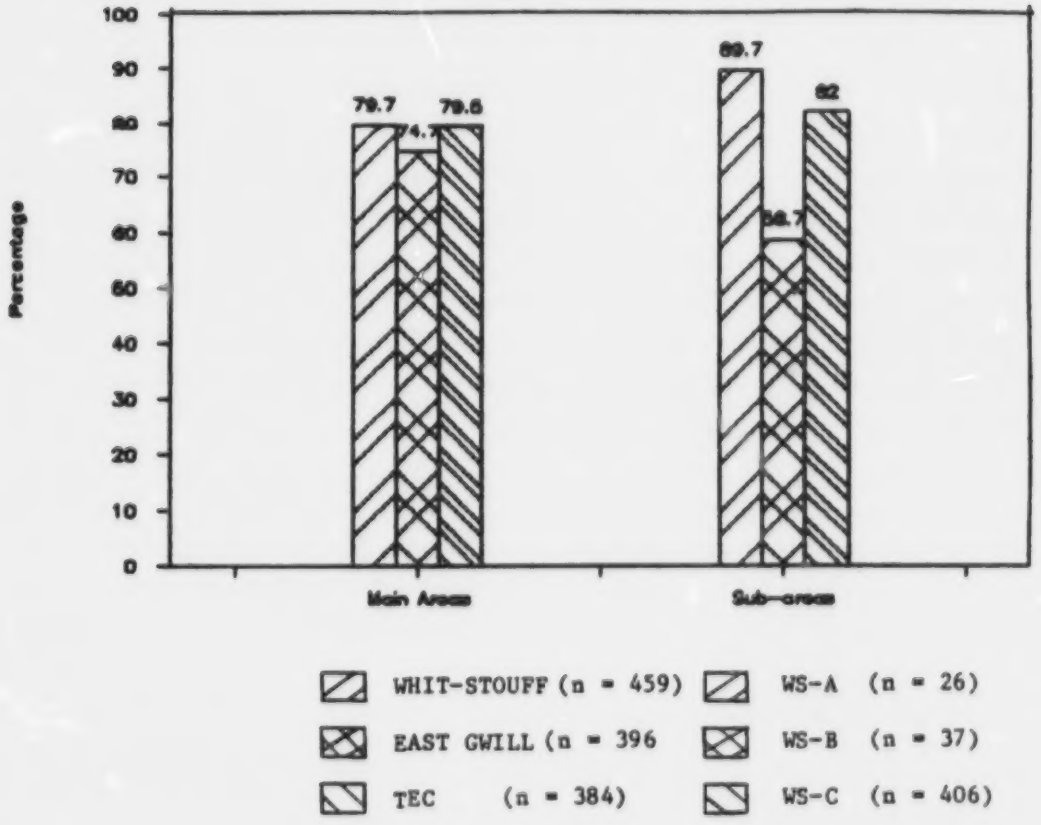
The number of households and individuals included in the survey is given in Table 6.1.1. This represents 12.3% of the population in the study areas. The response rates in WS, EG, and Tec were 85.3%, 84.8% and 84.2% respectively, giving an overall response rate of 84.8%. This is considered a very high response rate for a telephone survey of this nature. The percentage of telephone and personal (in-home) interviews are given in Figures 6.1.1 and 6.1.2 respectively. Table 6.1.2 gives a summary of the target and achieved sample sizes for the study. The size of the households (persons per household) had a similar distribution across the three areas (average size of household: 3.15 for WS, 3.24 for EG, and 3.26 for Tec).

TABLE 6.1.1: NUMBER OF HOUSEHOLDS AND PERSONS INCLUDED IN THE SURVEY RESULTS

AREA	NUMBER OF HOUSEHOLDS*	NUMBER OF PERSONS*	PERCENT OF TOTAL POPULATION
Whitchurch-Stouffville	576	1813	12%
East Gwillimbury	530	1715	12%
Tecumseth	484	1576	13%
WS-A	29	108	76%
WS-B	62	172	14%
WS-C	496	1582	12%

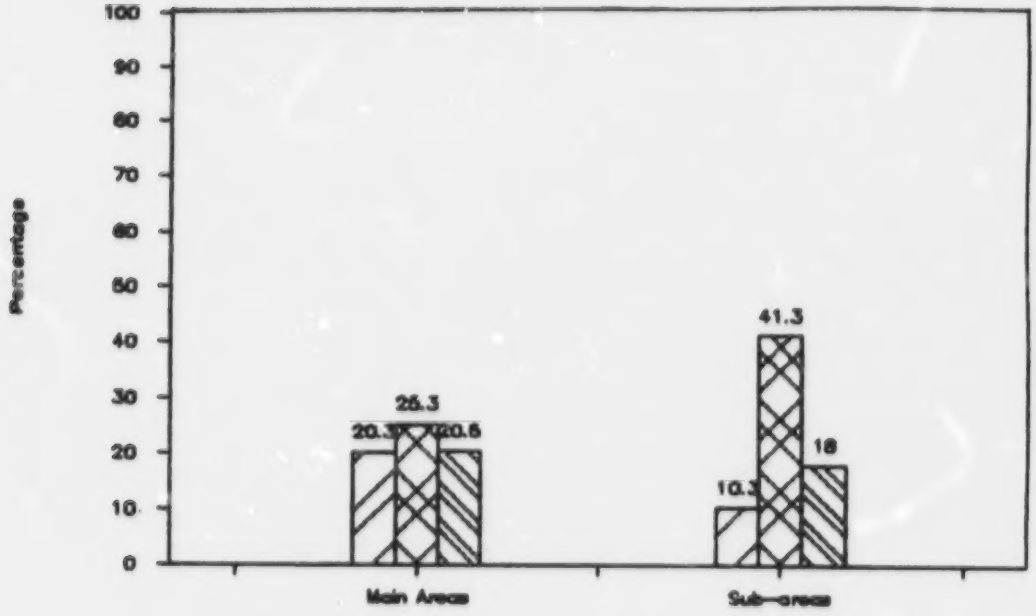
* Numbers include residents of residential institutions, where each such resident represents "one household"; namely, WS(24), EG(25), Tec(25), WS-A(0), WS-B(14), and WS-C(10).

FIGURE 6.1.1: TELEPHONE INTERVIEWS*



*Note: Much of the difference in WS-B versus the other areas is explained by the relatively higher number of institutionalized residents in WS-B.

FIGURE 6.1.2: PERSONAL INTERVIEWS*



*Note: Much of the difference in WS-B versus the other areas is explained by the relatively higher number of institutionalized residents in WS-B.

TABLE 6.1.2: SUMMARY OF TARGET AND ACHIEVED SAMPLE

INTERVIEW QUESTIONNAIRE

Area	Target Sample (Hhld)	Achieved Sample (Hhld)	Response Rate (Percent)
DL-I*			
WS	675	576	85
EG	625	530	85
Tec	575	484	84
Total	1875	1590	85
DL-II**			
WS-A	38	29	76
WS-B	76	62	82

BLOOD SAMPLING

DL-I*			
WS	100	66	66
EG	100	59	59
Tec	100	54	54
Total	300	179	60
DL-II**			
WS-A	20	14	70
WS-B	30	21	70

* Design Level-I: WS, EG, and Tec.

** Design Level-II: WS-A, WS-B, WS-C.
: Note that WS-C (numbers not shown here) was derived from DL-I:WS less samples located in WS-A and B, and averaged about 90% of the sample for DL-I:WS (see section 3.0).

Table 6.1.3 presents a summary of the reasons for refusal to the survey in the three main areas. The reasons were generally similar for the three areas and the two sub-areas (WS-A, WS-B), and therefore, no bias in comparisons is expected. Some original households had to be replaced in the survey, as outlined in section 3.0 and Appendix G under "replacement samples". Table 6.1.4 gives a summary of the reasons for replacement by area. The overall replacement sample rate of households averaged about 11%, with the three main study areas having replacement sample rates between 10 and 12%.

Of 1590 households, about 800 were selected for Medical Records Review. Due to logistic problems (e.g., doctors' strike), 365 reviews representing 202 households were completed. About 67% of all reported conditions were verifiable in the medical records, 8% had reported conditions not present in the medical records, and 12% had some condition(s) in the medical records not reported by the respondent in the survey. Thirteen percent of the records could not be verified due to time limitations or doctor's refusal. The results were similar for the three areas WS, EG, and Tec.

TABLE 6.1.3: SUMMARY OF REASONS FOR REFUSALS TO SURVEY (% DISTRIBUTION)

Too Busy/No Time/Not Interested	46%
Personal Reasons (Recent Death; Aged, etc.)	7%
Suspicious of Surveys/Government	5%
Invasion of Privacy (Too Personal)	14%
Medical Reasons	3%
Other Reasons (Including No Reason Given)	25%
TOTAL	100%
Sample Size (n) ...	233

TABLE 6.1.4: NUMBER OF SAMPLE REPLACEMENTS - SUMMARY OF REASONS BY AREA

	DESIGN LEVEL-I*			DESIGN LEVEL-II*
REASON***	WHIT-STOUFF	EAST GWILL	TEC	WS-B**
Cannot Locate	44	32	30	2
Unavailable	18	16	10	0
Moved/Moving	10	22	10	1
Office/Business/ Not in Area	9	5	5	0
Deceased	3	0	1	0
Inaccessible	0	1	2	0
TOTAL	84	76	58	3

* DL-I: WS, EG, Tec; DL-II:WS-A, WS-B, WS-C.

** WS-A was a census survey and no replacement was possible; WS-C replacements were part of Design Level-I: WS replacements.

*** Definitions of "Reason" are given in Glossary of Terms (Appendix G).

6.1.2 Demographic Characteristics

The reported age distribution of the three main study areas WS, EG and Tec as well as the sub-areas WS-A, WS-B, and WS-C are given in Figures 6.1.3 and 6.1.4. All areas and sub-areas had comparable age distributions.

Approximately 50% of the respondents were females in all three areas (Figure 6.1.5). There was no statistically significant difference in age distribution for males and for females between the three main areas. The size of the household was similar in the three areas: on average, WS - 3.15, EG - 3.24, and Tec - 3.26 persons per household.

The reported lengths of residency for the three main areas and sub-areas, expressed as a percentage of the total residents in the sample, are given in Figures 6.1.6 and 6.1.7 respectively. While there is no difference in the distribution of this parameter across the three main areas, WS-A had more residents who had lived there longer than 10 years (WS-A, 66%; WS-B, 36%; WS-C, 35%).

Socio-economic status of the residents in the three areas, as measured by reported educational status (Tables 6.1.5 and 6.1.6), income levels (Table 6.1.7), and occupational status (Table 6.1.8) are also comparable. Response rates were nearly 80% for these variables for all areas.

FIGURE 6.1.3: REPORTED AGE DISTRIBUTION OF RESPONDENTS FOR MAIN STUDY AREAS (expressed in %)

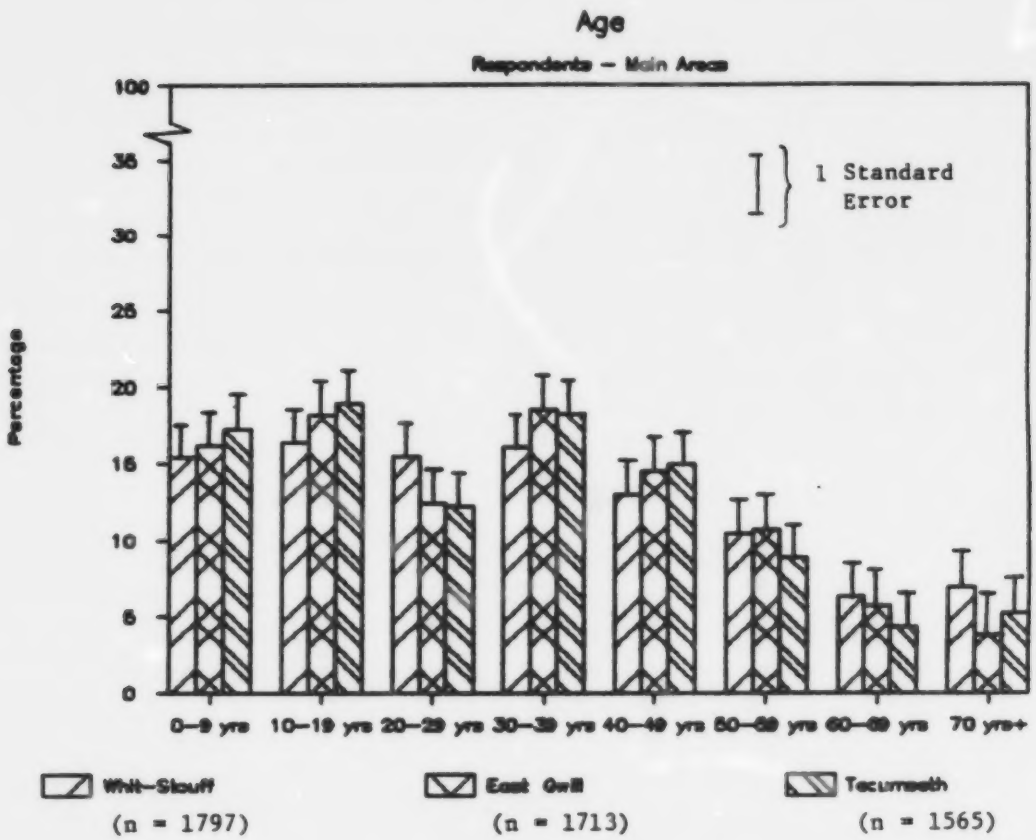


FIGURE 6.1.4: REPORTED AGE DISTRIBUTION OF RESPONDENTS FOR WHITCHURCH-STOUFFVILLE SUB-AREAS OF STUDY (expressed in %)

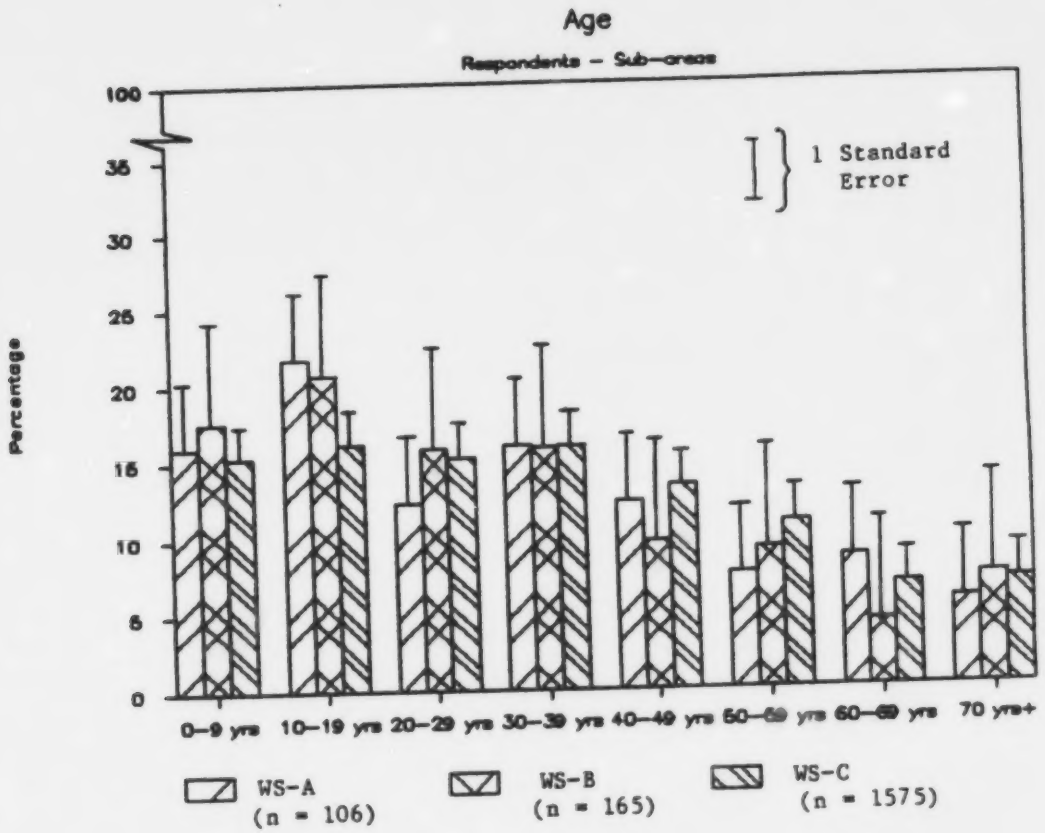


FIGURE 6.1.5: Percentage of Females in the Sample

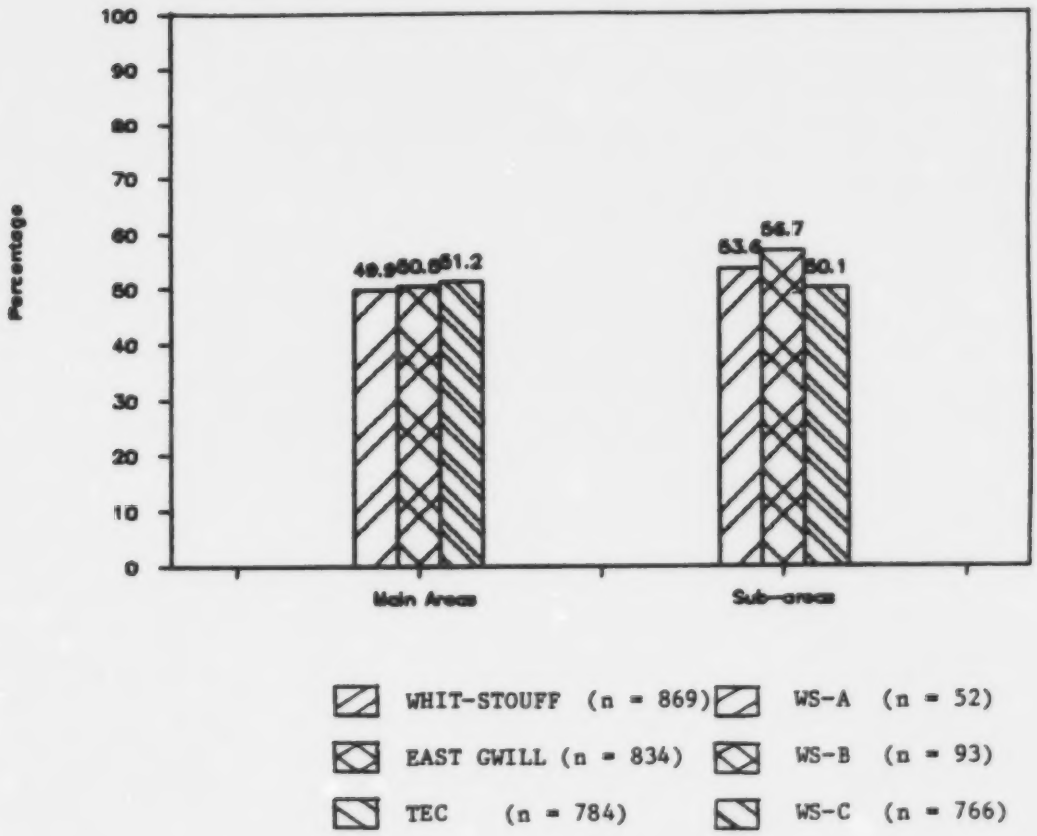
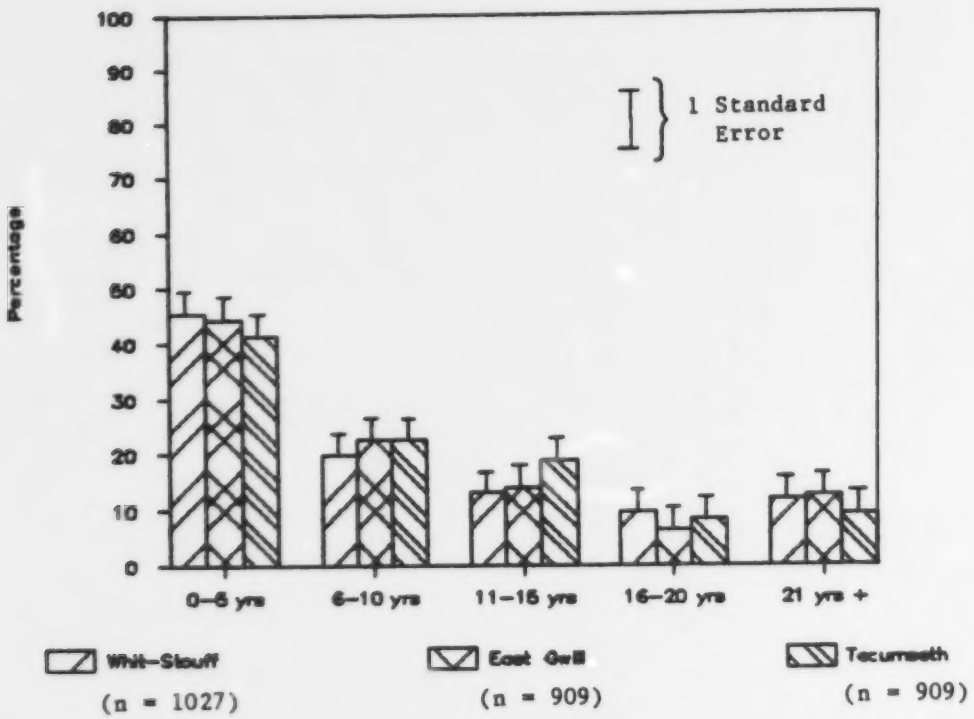


FIGURE 6.1.6: REPORTED LENGTH OF RESIDENCY FOR THE MAIN STUDY AREAS (as % of total residents in sample)



(n = 1027) (n = 909) (n = 909)

FIGURE 6.1.7: REPORTED LENGTH OF RESIDENCY FOR THE STUDY SUB-AREAS (as % of total residents in sample)

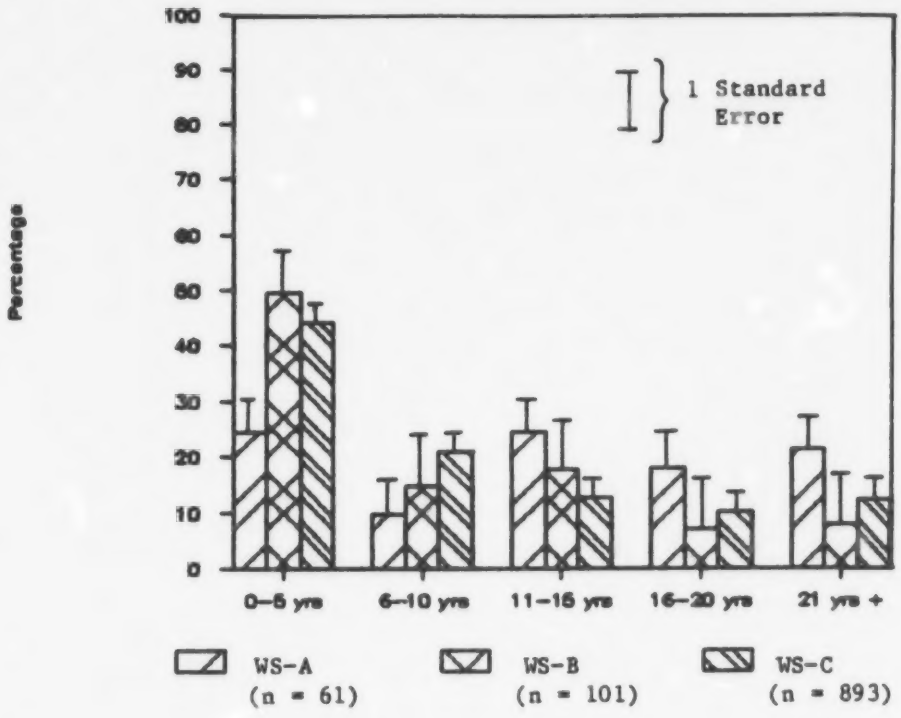


TABLE 6.1.5: REPORTED EDUCATIONAL STATUS OF PRIMARY RESPONDENT*
(expressed as percent)

ATTAINED EDUCATION LEVEL	% RESPONDENTS - MAIN AREAS		
	WHIT-STOUFF	EAST GWILL	TEC
Elementary School or Less	10.7	10.6	11.6
Partial High School	27.0	26.5	22.3
High School Completed	28.1	28.5	32.8
Post-Secondary	34.2	34.4	33.3
SAMPLE SIZE (n)	562	520	466

* Primary respondent was typically the woman of the household.

TABLE 6.1.6: REPORTED EDUCATIONAL STATUS OF SPOUSE**
(expressed as percent)

ATTAINED EDUCATION LEVEL	% RESPONDENTS - MAIN AREAS		
	WHIT-STOUFF	EAST GWILL	TEC
Elementary School or Less	11.8	8.1	9.1
Partial High School	22.3	28.5	26.3
High School Completed	25.4	23.5	31.8
Post-Secondary	40.5	39.9	32.8
SAMPLE SIZE (n)	461	442	384

** Typically, the man of the household.

TABLE 6.1.7: REPORTED HOUSEHOLD INCOME
(expressed as percent)

HOUSEHOLD INCOME* ($000)	% RESPONDENTS - MAIN AREAS		
	WHIT-STOUFF	EAST GWILL	TEC
Less than 30	33.7	28.7	34.4
30 - 50	38.2	43.2	43.6
Over 50	28.1	28.1	22.0
Average Income**	36,896	37,765	36,098
Sample Size (n)	501	463	419

* Household income defined as "total annual/gross household income" for the last twelve months.

** Average income (expressed in dollars) defined as arithmetic average.

TABLE 6.1.8: REPORTED OCCUPATIONAL STATUS OF WORKING RESPONDENT* (expressed in percent)

OCCUPATIONAL STATUS**	% RESPONDENTS - MAIN AREAS		
	WHIT-STOUFF	EAST GWILL	TEC
Professional, Semi-professional, Executive	28.5	29.6	27.6
Clerical, Sales	27.4	25.4	23.3
Skilled, Semi-skilled	37.4	38.7	42.2
Unskilled Manual	4.9	5.1	6.3
Not in Labour Force	1.8	1.2	0.6
SAMPLE SIZE (n)	820	743	682

* Working respondent involved both the primary respondent and spouse if both members of the household "worked most of the last two weeks" (excluding housework, school, retired).

**Occupational status definitions were derived using a collapsed version of Statistics Canada's definitions for major occupation groups used in their labour surveys (see Appendix E).

6.1.3 Health Indicators

Short-term health conditions. Health problems in the past two weeks were reported for 30% of the respondents in WS, 29% in EG and 30% in Tec. Tables 6.1.9 - 6.1.10 give the distribution of responses to the 7 questions on short-term health conditions for the main study areas and WS sub-areas respectively. WS and Tec residents reported similar prevalence of symptoms. WS residents had higher rates for most of the symptoms compared to EG and the difference in rates for upset stomach, loss of appetite and diarrhea were statistically significant ($p \leq .05$).

In order to assess the severity of these reported conditions, visits to the physicians for the conditions **and** days confined to bed **or** lost work days due to the conditions (which are all behavioural indicators of the severity of reported health problem) were looked at in detail. No significant differences between WS, EG, and Tec were observed for these surrogate measures of severity.

Headaches were significantly more frequent in sub-area A of WS, while upset stomach and diarrhea had significantly lower frequencies ($p \leq .05$).

Long-term health conditions. Long-term health problems in the past twenty years were reported for 37%, 36%, and 37% of the respondents in WS, EG, and Tec respectively. The relative frequency of reported symptoms were compared between the three areas. Tables 6.1.11 - 6.1.12 list the conditions and the relative frequencies in the main study areas and WS sub-areas respectively. All statistical significance (at .05 level) calculations are done on a per-comparison basis. If one allows for multiple comparisons, the significance levels chosen will have to be much more stringent (e.g., $p = .01$ or less), which would then make the observed, statistically significant differences to be declared **not significant**.

Only two conditions showed statistically significantly higher survey prevalence in WS compared to EG and Tec. These were: (i) intestinal disorders, and (ii) serious back problems. Intestinal disorders, which

TABLE 6.1.9: PERCENTAGE RESPONDENTS REPORTING SHORT-TERM HEALTH PROBLEMS FOR MAIN STUDY AREAS (± STANDARD ERROR)

SHORT-TERM HEALTH PROBLEM	MAIN STUDY AREAS		
	WHIT-STOUFF	EAST GWILL	TEC
Upset Stomach	* 10.5 ± 0.67	7.8 ± 0.61	10.0 ± 0.70
Dizziness	4.5 ± 0.46	3.5 ± 0.42	3.6 ± 0.44
Loss of Appetite	* 4.9 ± 0.48	3.2 ± 0.40	4.9 ± 0.51
Sleeping Problem	10.5 ± 0.67	9.4 ± 0.66	9.9 ± 0.70
Headaches	12.0 ± 0.72	12.9 ± 0.76	13.1 ± 0.79
Weight Loss	2.2 ± 0.32	1.5 ± 0.28	2.2 ± 0.34
Diarrhea	* 7.8 ± 0.59	4.8 ± 0.48	6.7 ± 0.59

* significant at 5% compared to EG.

TABLE 6.1.10: PERCENTAGE RESPONDENTS REPORTING SHORT-TERM HEALTH PROBLEMS FOR SUB-AREAS OF STUDY (± STANDARD ERROR)

SHORT-TERM HEALTH PROBLEM	WHITCHURCH-STOUFFVILLE (WS) SUB-AREAS		
	WS-A	WS-B	WS-C
Upset Stomach	7.4 ± 1.20	* 14.0 ± 2.45	9.9 ± 0.71
Dizziness	1.9 ± 0.62	3.5 ± 1.31	4.3 ± 0.48
Loss of Appetite	2.8 ± 0.78	5.2 ± 1.57	4.3 ± 0.48
Sleeping Problem	5.6 ± 1.08	9.9 ± 4.46	10.4 ± 0.72
Headaches	* 17.6 ± 1.80	12.2 ± 2.31	11.5 ± 0.57
Weight Loss	0.9 ± 0.45	2.9 ± 1.19	2.0 ± 0.33
Diarrhea	6.5 ± 1.16	* 9.9 ± 4.46	7.6 ± 0.63

* significant at 5% compared to (from top to bottom of listed problems) WS-A, WS-B and C, and WS-A.

TABLE 6.1.11: PERCENTAGE RESPONDENTS REPORTING LONG-TERM HEALTH PROBLEMS FOR MAIN STUDY AREAS (± STANDARD ERROR)

MAIN STUDY AREAS

LONG-TERM HEALTH PROBLEM	WHIT-STOUFF	EAST GWILL	TEC
Arthritis	*↑ 20.8 ± 1.25	16.5 ± 1.17	22.8 ± 1.38
Allergies/Hay Fever	35.8 ± 1.48	35.6 ± 1.50	33.2 ± 1.55
Skin Rashes/Problems	**↓ 20.6 ± 1.25	24.6 ± 1.35	23.1 ± 1.39
Migraines	13.4 ± 1.05	15.5 ± 1.14	16.1 ± 1.16
High Blood Pressure	14.3 ± 1.08	11.5 ± 1.01	11.8 ± 1.02
Heart Disease	6.0 ± 0.73	4.3 ± 0.64	7.0 ± 0.79
Emotional Disorders	3.3 ± 0.55	3.4 ± 0.55	3.2 ± 0.55
Emphysema/Bronchitis	6.7 ± 0.79	6.2 ± 0.74	6.3 ± 0.75
Anemia	4.5 ± 0.39	5.2 ± 0.41	4.1 ± 0.38
Diabetes	3.4 ± 0.55	2.7 ± 0.51	4.2 ± 0.64
Thyroid Problems	4.4 ± 0.64	3.4 ± 0.55	3.2 ± 0.55
Asthma	4.9 ± 0.67	5.3 ± 0.70	6.9 ± 0.81
Stomach Ulcer	5.3 ± 0.69	5.1 ± 0.69	5.2 ± 0.70
Liver Disorders	1.3 ± 0.37	1.2 ± 0.37	1.2 ± 0.38
Leukemia	0.1	0.1	0.0
Other Cancer	3.0 ± 0.52	3.2 ± 0.53	3.2 ± 0.55
Pneumonia	9.2 ± 0.89	7.9 ± 0.82	9.6 ± 0.93
Intestinal Disorders	*#↑ 8.3 ± 0.86	5.7 ± 0.72	5.6 ± 0.72
Multiple Sclerosis	0.2	0.2	0.1
Parkinson's Disease	0.2	0.0	0.2
Cerebral Palsy	0.0 (See	0.2 (See	0.2 (See
Mental Retardation	0.5 Note:	0.5 Note:	0.2 Note:
Epilepsy	1.1 Below)	0.7 Below)	1.1 Below)
Kidney Disease	2.0	3.2	2.7
Paralysis	0.8	0.7	1.0
Infertility	1.5	2.1	1.3
Serious Back Trouble	*#↑ 15.3 ± 1.11	11.9 ± 1.02	12.4 ± 1.05
Ser.Trouble Legs/Hip	7.8 ± 0.78	7.1 ± 0.77	6.9 ± 0.77
Ser.Trouble Arms	4.4 ± 0.64	5.1 ± 0.68	3.8 ± 0.62
Ser.Trouble Bones	2.0	2.7	3.4
Ser.Trouble Hand/Feet	2.8	3.8	3.1
Ser.Trouble Memory	1.0	1.3	1.2
Other Problems	13.7 ± 1.06	11.4 ± 1.01	11.9 ± 1.02
Total Respondents	1056	1013	925

[1] Alzheimer's disease was omitted from listing, as no cases were reported in the survey.

* Significantly higher (↑) than EG (at 5% significance level).

\# Significantly higher (↑) than Tec (at 5% significance level).

**Significantly lower (↓) than EG and Tec (at 5% significance level).

Note: some table entries have no standard error shown; sample frequencies were very small in these instances. Statistical comparisons with these cells are not appropriate.

TABLE 6.1.12: PERCENTAGE RESPONDENTS REPORTING LONG-TERM HEALTH PROBLEMS FOR SUB-AREAS OF STUDY (± STANDARD ERROR)

LONG-TERM HEALTH PROBLEM	WHITCHURCH-STOUFFVILLE (WS) SUB-AREAS		
	WS-A	WS-B	WS-C
Arthritis	25.8 ± 5.39	21.0 ± 3.73	21.3 ± 1.36
Allergies/Hay Fever	42.4 ± 6.08	35.3 ± 4.37	36.3 ± 1.69
Skin Rashes/Problems	22.7 ± 5.16	29.4 ± 4.03	19.8 ± 1.32
Migraines	22.7 ± 5.16	12.6 ± 3.04	13.8 ± 1.14
High Blood Pressure	10.6 ± 3.79	14.3 ± 3.56	14.5 ± 1.18
Heart Disease	6.1 ± 2.95	5.9 ± 2.16	5.8 ± 0.77
Emotional Disorders	3.0 ± 2.10	3.4 ± 1.66	3.1 ± 0.57
Emphysema/Bronchitis	3.0 ± 2.10	7.6 ± 2.32	6.4 ± 0.79
Anemia	1.5 ± 1.50	6.7 ± 2.19	4.2 ± 0.66
Diabetes	4.5 ± 2.55	4.2 ± 1.74	3.2 ± 0.57
Thyroid Problems	4.5 ± 2.55	1.7 ± 1.19	4.2 ± 0.66
Asthma	3.0 ± 2.10	3.4 ± 1.66	4.7 ± 0.69
Stomach Ulcer	3.0 ± 2.10	4.2 ± 1.74	5.5 ± 0.75
Liver Disorders	1.5 ± 1.50	0.8 ± 0.30	1.4 ± 0.39
Leukemia	0.0	0.8	0.0
Other Cancer	1.5 ± 1.50	3.4 ± 1.66	3.2 ± 0.57
Pneumonia	4.5 ± 2.55	10.1 ± 2.76	9.5 ± 0.97
Intestinal Disorders	7.6 ± 3.26	7.6 ± 2.43	7.7 ± 0.89
Multiple Sclerosis	0.0	0.0	0.2
Parkinson's Disease	0.0	0.0	0.2
Mental Retardation	0.0 (see	0.0 (see	0.3 (see
Epilepsy	1.5 Note:	0.0 Note:	1.0 Note:
Kidney Disease	1.5 below)	0.8 below)	2.0 below)
Paralysis	0.0	0.0	0.8
Infertility	1.5	0.8	1.3
Serious Back Trouble	12.1 ± 4.01	16.8 ± 3.43	15.3 ± 1.19
Ser.Trouble Legs/Hip	4.5 ± 2.55	9.2 ± 2.64	7.8 ± 0.89
Ser.Trouble Arms	3.0 ± 2.10	4.2 ± 1.74	4.0 ± 0.65
Ser.Trouble Bones	3.0 ± 2.10	1.7 ± 1.19	2.1 ± 0.46
Ser.Trouble Hand/Feet	0.0	2.5	2.9
Ser.Trouble Memory	0.0	1.7	0.9
Other Problems	10.6 ± 3.79	10.9 ± 2.86	13.8 ± 1.14
Total Respondents	66	119	911

[1] Alzheimer's disease was omitted from listing, as no cases were reported in the survey.

Note: some table entries have no standard error shown; sample frequencies were very small in these instances. Statistical comparisons with these cells are not appropriate.

could be a result of exposure to bacterial or chemical contamination of drinking water, had a reported prevalence of 8.3 percent over a 20 year period. There was no specific time period where this was more of a problem than other times. Moreover, no difference was observed between WS-A, WS-B, and WS-C. Back problems had a reported prevalence of 15.3 percent over 20 years. This again did not show any marked increase in any specific time period, and had a lower prevalence in WS-A compared to WS-B and WS-C.

Arthritis had a reported prevalence rate of 20.8 percent in WS, which was significantly higher ($p \leq .05$) than the rate in EG, but lower than Tec. Skin rashes were significantly lower in WS compared to EG and Tec.

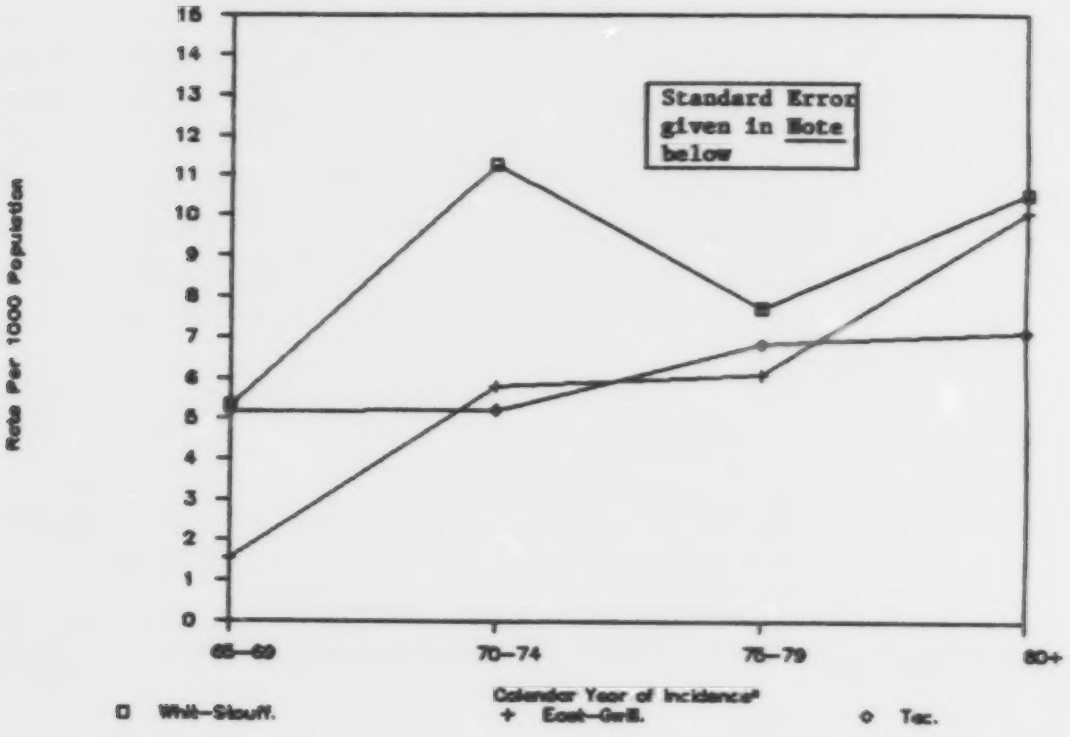
Although the age distribution and the distribution of length of residence were similar for the three areas, the survey reported prevalence rates were adjusted for these variables using the distribution of the combined population as standard (since the distributions were not identical). The results were the same as with the unadjusted rates. Therefore, the adjusted rates are not presented in these tables.

We also looked at specific 5 year periods in which these illnesses were reported in order to follow trends and to identify if a higher prevalence was reported during the period when the landfill site was fully operational. Hay fever/allergies showed increasing prevalence over time for the three areas. Both WS and EG had similar trends over time (Figure 6.1.8). Reported prevalence rate of intestinal disorders was consistently higher for WS compared to EG and Tec over the period. However, the incidence is very small in the order of 1 per 500 population per year (Figure 6.1.9).

Detailed analysis of health problems (e.g., cancer incidence) was done to identify any possible household clustering. No such clustering effect was evident.

Considering the total number of long-term health problems reported as an index of overall illness, there was little or no difference in the health status of respondents from WS, EG, and Tec during the 20 year period under question.

FIGURE 6.1.8: AVERAGE ANNUALIZED, AGE-ADJUSTED, REPORTED INCIDENCE RATES FOR HAY FEVER OR OTHER ALLERGIES

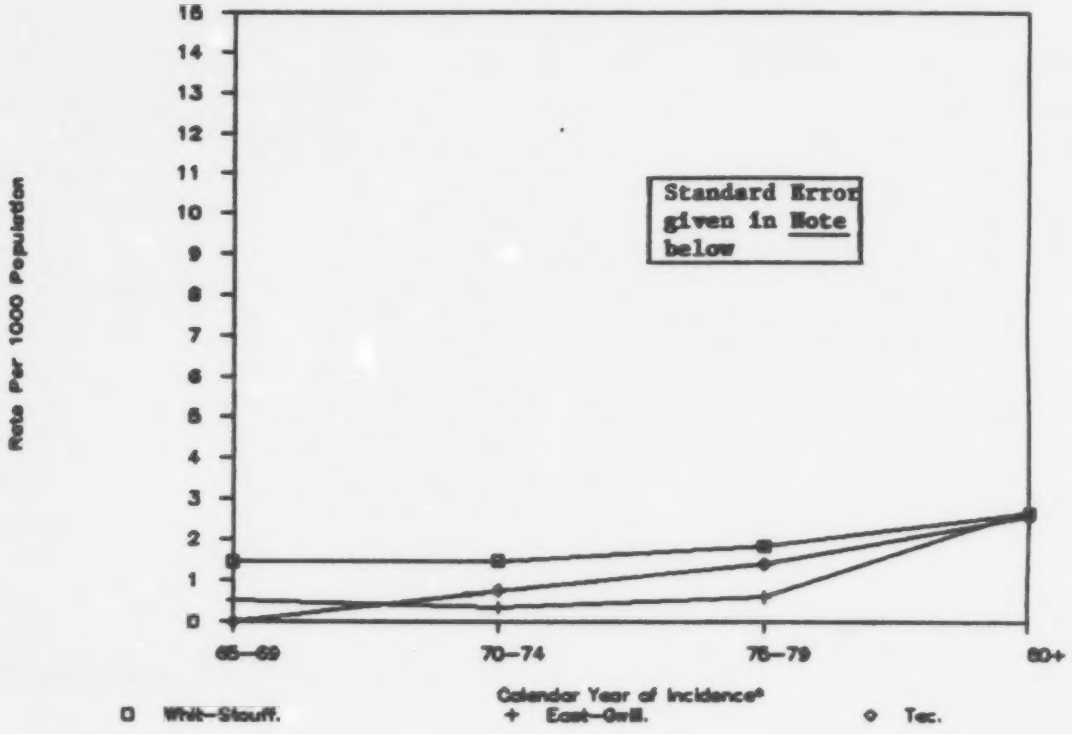


* based on the population resident during the period and the condition reported to have started during the period.

Note: Standard errors are given in the table below:

Area	65-69	70-74	75-79	80+
WS (n = 175)	3.6	4.1	2.8	2.5
EG (n = 148)	2.1	3.2	2.6	2.5
Tec (n = 118)	4.3	3.1	2.8	2.2

FIGURE 6.1.9: AVERAGE ANNUALIZED, AGE-ADJUSTED, REPORTED INCIDENCE RATES FOR INTESTINAL OR BOWEL DISORDERS



* based on the population resident during the period and the condition reported to have started during the period.

Note: Standard errors are given in the table below:

Area	65-69	70-74	75-79	80+
WS (n = 47)	1.9	1.5	1.4	1.3
EG (n = 32)	1.2	0.8	0.8	1.3
Tec (n = 32)	0.0	1.2	1.3	1.3

The patterns were generally similar in the WS sub-areas. No statistically significant differences were identified. However, arthritis, allergies/hayfever and migraines showed a consistently higher rate of prevalence for WS-A compared to WS-B and WS-C. On the other hand, high blood pressure, emphysema, anemia, asthma, stomach ulcer, cancer, pneumonia, trouble with back, arms and legs, all showed consistently lower prevalence for WS-A. Intestinal disorders had a similar prevalence rate for the three WS sub-areas. Again, adjusting for age and length of residency did not change the results. No noticeable increase in reported prevalence was observed for any specific time period.

The 20-year prevalence rates from our survey were ranked in order of prevalence and compared with the rank order of 1 year prevalence rates for Ontario based on the Canada Health Survey of 1978-79. (Since the period of observation was different for the two studies, the rates could not be used for comparison.) Table 6.1.13 gives the 5 highest ranking long-term conditions and their ranks in the two surveys. The most prevalent conditions were essentially the same in the three areas compared to Ontario.

TABLE 6.1.13: RANK ORDER OF PREVALANCE OF LONG-TERM CONDITIONS

CHRONIC PROBLEMS	WS	EG	TEC	ONTARIO (CAN. H.S.)*
Allergies/Hay Fever	1	1	1	1
Arthritis	2	2	2	2
Skin Problems	3	3	3	3
High Blood Pressure	5	4	4	4
Migraines	4	5	5	5

* Canada Health Survey (see section 4.2 for details and reference).

Reported "Other Cancers" (from the Interview Questionnaire) were analyzed in detail, particularly, for the relative prevalence of specific cancers. While no statistically significant differences for all area/sub-area comparisons were found, some cancers showed different rates for the three main areas. Breast cancer had a higher reported rate in WS than EG or Tec. When the specific areas were cross-checked with medical records, we could not verify all of the survey reported cases and up to 10% over-reporting may have occurred. It should also be noted that the number of reported cancer cases is small.

6.1.4 Reproductive Outcomes

One of the major concerns of the local residents with respect to possible adverse health effects from contamination resulting from the landfill site was outcomes of pregnancy. Accordingly, a detailed history of pregnancies was collected from the survey sample. All outcomes of pregnancies while resident in the study areas were tabulated and examined for differences in distribution between the three areas and the two sub-areas of WS. Table 6.1.14 gives the primary outcome of pregnancy reported by the survey in the three areas, classified by the number of years resident in the township at the time of the outcome. The rates of survey reported miscarriage (spontaneous abortion) and the rates of reported stillbirth are given in Table 6.1.15 for the entire time period while resident in the township. The rate of reported miscarriage was also analyzed by 5 year periods and found to be highest for WS for the period 1971-75, but this difference was not statistically significant. This was based on 7 miscarriages out of a total of 28 pregnancies. Moreover, many of the reported miscarriages could not be verified from the medical records (23% of available records).

Reported miscarriages and stillbirths were also analyzed by the age of the mother and other possible risk factors, such as smoking and consumption of alcohol. There were no significant changes in the rates mainly because of the small numbers of cases reported. There were very few reported miscarriages and stillbirths in the sub-areas WS-A and WS-B to allow any meaningful analysis. The number of birth defects, both major and minor, also showed no statistically significant elevation in WS-A or WS-B compared to WS-C, or in WS compared to EG and Tec.

In order to analyze the confounding effect of risk factors of pregnancy (e.g., age of mother; maternal smoking; etc.), the reported sample distributions of these factors were compared between the three main study areas and the three WS sub-areas. No statistically significant differences were found; and therefore, no attempt was made to adjust for these variables in the subsequent analysis.

TABLE 6.1.14: SURVEY REPORTED NUMBER OF LIVE BIRTHS [MISCARRIAGE] (STILLBIRTH) WHILE RESIDENT IN TOWNSHIP

MAIN STUDY AREAS

YEARS IN TOWNSHIP AT BIRTH	WHITCHURCH-STOUFFVILLE	EAST GWILLIMBURY	TECUMSETH
5 or less	232 [34](5)	250 [29](5)	243 [30](2)
6 - 10	74 [8](0)	72 [11](0)	62 [6](0)
11 - 15	21 [7](0)	21 [4](0)	17 [3](0)
15 or more	65 [12](0)	83 [12](1)	62 [9](1)
Not Available/ Unknown	25 [31](0)	29 [36](1)	12 [36](1)
TOTAL	417 [92](5)	455 [92](7)	396 [84](4)

TABLE 6.1.15: SURVEY REPORTED RATES OF MISCARRIAGES AND STILLBIRTHS WHILE RESIDENT IN TOWNSHIP (PER 1000 LIVEBIRTHS ± STANDARD ERROR)

MAIN STUDY AREAS

MAIN STUDY AREA	SURVEY REPORTED MISCARRIAGES	SURVEY REPORTED STILLBIRTHS
Whitchurch-Stouffville	221 ± 20.3	11.99 ± 5.33
East Gwillimbury	202 ± 18.8	15.38 ± 5.77
Tecumseth	212 ± 20.5	10.10 ± 5.02

6.1.5 Congenital Anomalies

Birth defects were noted for any pregnancy reported for the period in which the respondent was living in the appropriate township. The survey reported birth defect rates (number of birth defects per 1000 livebirths) were not significantly different for the three areas, nor for the two sub-areas. The reported birth defects were then individually analyzed to take into account the severity of the problem (e.g., to eliminate such "reported defects" as birth marks/moles) and to isolate defects that have been associated with chemical contamination of drinking water in previous studies. This detailed analysis included the verification of any household clustering. No such clustering was found in any of the three areas. The defects were grouped into major and minor defects. The major defects included those shown in Table 6.1.16. Table 6.1.17 gives the distribution of the major defects in the three areas along with the odds-ratios (a measure of the relative risk of disease for exposed as compared to unexposed individuals). There is a very slight increase in the odds-ratio for WS compared to EG, but lower odds-ratio as compared to Tec. Neither difference is statistically significant. The defects more commonly associated with specific etiologies such as Down syndrome and neural tube defects (spina bifida), either did not occur or had a very low incidence.

Birthweight was compared for the three areas. The average birthweight (expressed in kilograms) was 3.36 ($\pm$ 0.50) for WS, 3.36 ($\pm$ 0.54) for EG and 3.43 ($\pm$ 0.55) for Tec. The overall distribution of birthweights and the incidence of low birthweights were also similar between the areas.

TABLE 6.1.16: MAJOR BIRTH DEFECTS

SELF-REPORTED CONDITION FOR "BIRTH DEFECT"	ICD9-ASSIGNED CODE AND DESCRIPTION*
• Lump on spine	• Spina Bifida (741)
• Hydrocephalus	• Hydrocephaly (742)
• Heart disease/defect/condition; hole in heart; blue baby; leaking heart valve	• Heart Defect/Murmur (745/746)
• Brain hemorhage; artery in umbilical cord; veins clustered together	• Circulatory System (747)
• Hole in lung; premature lungs; breathing problem first two weeks; congenital atelectasis	• Breathing Problems (748)
• Cleft lip; cleft palate; paralysed cleft palate	• Cleft Palate/Lip (749)
• Malignant lump on throat and jaundice; pyloric stenosis	• Upper Alimentary Tract (750)
• Malrotation/intestine twisted	• Digestive System (751)
• No kidney; chronic renal failure; three kidneys	• Urinary System (753)
• Muscular skeleton defect	• Musculoskeletal (754/756)
• Down syndrome	• Chromosomal (758)
• Dwarf	• Others (759)

* defined in Study as "Major Birth Defects".

TABLE 6.1.17: REPORTED MAJOR BIRTH DEFECTS WHILE RESIDENT IN TOWNSHIP

AREA	REPORTED MAJOR DEFECTS+		TOTAL LIVEBIRTHS
	YES	NO	
WS	15	402	417
EG	13	442	455
Tec	14	382	396

ODDS (RISK) RATIOS

WS:EG = 1.26 (0.56, 2.87)*
WS:Tec = 1.02 (0.45, 2.27)*

+ major defects defined in Table 6.1.16.

* 95% confidence interval estimate for odds ratio.

6.1.6 Use of Water

Information on the residents' use of drinking water was obtained to determine the degree of actual exposure to potentially contaminated water. Tables 6.1.18 and 6.1.19 give the type of drinking water currently being used and the length of time used. Approximately 50% of the residents in each township use well water as their main source of drinking water, and there is no significant difference between the three areas. About thirty-six (36) percent of all the respondents have been using their main source of water for more than 10 years. About twenty (20) percent of the respondents use a secondary source of drinking water in addition to the main source. Again, WS is not much different from the other two areas in this respect.

In WS-A, B, and C, about 50% of respondents in sub-areas A and C use well water as their main source, while 95% of residents in sub-area B use well water. Some of the residents in sub-area A, which is the closest area to the landfill site, have received direct connections to the municipal water supply in the early 1980's, as they were concerned about the contamination of their well water*. In addition to this availability of municipal water, some of the residents of WS-A also use bottled water as a secondary source.

Awareness of problems with drinking water was probed using five pretested questions on possible contamination and the scientific knowledge of the effects and solutions to such contamination. In addition, a separate question addressed the resident's satisfaction with the quality of their drinking water. Generally, WS, EG, and Tec, and WS-A and WS-B responded similarly.

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* Hydrogeological considerations (MacLaren Report; Appendix D) suggest that the principal route of off-site contaminant migration is via the regional aquifer underlying the site. Sampling that has been undertaken over the years indicates that some inorganic contaminants (e.g., chloride) and phenols have migrated off-site. However, groundwater quality within the regional aquifer at the property boundary is not severely impacted and no parameters have exceeded the provincial water quality criteria in any private wells off-site as a result of the landfilling operations.

TABLE 6.1.18: MAIN SOURCE OF DRINKING WATER
(± STANDARD ERROR)
(as % of total residents)

AREA	WELL	TOWN	OTHER*
Whitchurch-Stouffville (n = 565)	51 ± 2.08	47 ± 2.08	2
East Gwillimbury (n = 523)	54 ± 2.27	42 ± 2.15	4
Tecumseth (n = 466)	47 ± 2.17	48 ± 2.17	5

* numbers too small for computation of standard error.

TABLE 6.1.19: LENGTH OF TIME MAIN SOURCE OF WATER USED
(as % of total residents)

AREA	LESS THAN 5 YEARS	6-10 YEARS	11-15 YEARS	16-20 YEARS	MORE THAN 20 YEARS
Whitchurch-Stouffville (n = 561)	44.5	18.9	13.4	9.3	13.9
East Gwillimbury (n = 513)	50.7	26.3	10.9	4.5	7.6
Tecumseth (n = 461)	41.2	21.9	19.1	9.1	8.7

6.1.7 Confounders

As discussed in the analysis section (5.0), information on several variables which could be affecting health and are unrelated to contamination or use of drinking water, were collected. These are age, sex, and socioeconomic status. These variables were, as detailed in the demographic section 6.1.2, comparable in all study areas. Accordingly, adjustment for these variables was not necessary in the subsequent analyses except for age and length of residence and period of residence.

Nevertheless, as a confirmatory (conservative) approach to the analysis, adjustment for age was carried out in many of the comparisons. Length of residence in the current area of residence is another potential source of confounding. All the comparisons were adjusted for period of residency and length of residency and no substantial differences were noted in the results.

Tables 6.1.20 - 6.1.22 show the reported regular physical activity and prevalence of tobacco and alcohol use respectively for respondents 15 years and over in the main study areas. The use of tobacco and alcohol, exercise, and work history were also not found to differ between the various areas and sub-areas and were not adjusted for.

A major concern is the potential bias which may result from outmigration from the township. The study design included those residents who moved out of their residence in WS, EG, Tec and WS-A, B or C but remained within the township. The respondents were asked whether they knew of the previous residents, where they moved to, and whether they were aware of any health problems the previous residents may have had. None of these variables were distributed differently for WS, EG, and Tec and WS-A, B or C. The length of residency in the current township was similar for the three main areas. Within WS, WS-A had proportionately more long-term residents than WS-B and WS-C. This helps to overcome some of the bias due to migration.

TABLE 6.1.20: REPORTED REGULAR PHYSICAL ACTIVITY*

REGULAR PHYSICAL ACTIVITY	% RESPONDENTS - MAIN AREAS		
	WHIT-STOUFF	EAST GWILL	TEC
Yes	56.8	57.6	59.6
No	43.2	42.4	40.4
SAMPLE SIZE (n)	1311	1223	1083

TABLE 6.1.21: REPORTED USE OF TOBACCO*

USE OF TOBACCO	% RESPONDENTS - MAIN AREAS		
	WHIT-STOUFF	EAST GWILL	TEC
Yes	51.1	49.2	51.6
No	48.9	50.8	48.4
SAMPLE SIZE (n)	1341	1251	1110

TABLE 6.1.22: REPORTED USE OF ALCOHOL*

USE OF ALCOHOL	% RESPONDENTS - MAIN AREAS		
	WHIT-STOUFF	EAST GWILL	TEC
Yes	74.1	75.5	77.9
No	25.9	24.5	22.1
SAMPLE SIZE (n)	1341	1251	1110

* For respondents 15 years and over (see Appendix C - Health Questionnaire, Section IX (Lifestyles) for specific questions posed to respondents).

6.2 BLOOD RESULTS

As an indicator of current health and possibly future health, blood collected from a sub-sample of respondents was analyzed for various parameters. Table 6.2.1 gives the number of samples of blood collected from each of the areas. Table 6.2.2 gives the results of the parameters: hemoglobin, hematocrit, white blood cell count, blood film examination, total cholesterol and liver enzymes (aspartate transaminase, alanine transaminase and alkaline phosphatase).

None of these parameters differed substantially between the areas. The parameters were dichotomized (Normal and Abnormal) according to the laboratory standards for the age and sex of the respondent. Again, no difference in distributions was detected. Total serum cholesterol and red blood cell morphology for sub-area B of WS were different from EG, Tec, and WS-A and C. The increase in cholesterol was not associated with any difference in other parameters.

The parameters were also analyzed separately for the two age groups, 5-18 years and over 18. Again, no significant differences were observed among all areas.

TABLE 6.2.1: BLOOD SAMPLES COLLECTED

AREA	NUMBER OF BLOOD SAMPLES	PERCENT OF POPULATION
Whitchurch-Stouffville	158	1.05
East Gwillimbury	145	1.02
Tecumseth	130	1.07
WS-A	34	24.0
WS-B	58	4.7
WS-C	117	0.9

TABLE 6.2.2: RESULTS OF BLOOD ANALYSIS (MEAN ± STANDARD ERROR)

BLOOD TEST	MAIN AREA			SUB-AREA		
	WHITCHURCH-STOUFFVILLE	EAST GWILLIMBURY	TECUMSETH	WS-A	WS-B	WS-C
Hemoglobin (g/l)	139.85 ±13.10 (n=158)	138.38 ±12.54 (n=145)	141.29 ±12.33 (n=130)	142.92 ±13.20 (n=38)	141.45 ±14.02 (n=58)	139.38 ±13.53 (n=117)
Hematocrit	0.41 ± 0.04 (n=158)	0.40 ± 0.04 (n=145)	0.41 ± 0.04 (n=130)	0.42 ± 0.04 (n=38)	0.41 ± 0.04 (n=58)	0.41 ± 0.04 (n=117)
White Blood Cell Count (X 10E9/1)	7.56 ± 1.88 (n=158)	7.44 ± 1.89 (n=145)	7.80 ± 1.92 (n=130)	7.24 ± 2.18 (n=38)	7.48 ± 1.76 (n=58)	7.41 ± 1.80 (n=117)
Blood Film Examination[1] .Neuts .Lymph	0.58 ± 0.11 0.36 ± 0.11 (n=158)	0.56 ± 0.11 0.37 ± 0.10 (n=145)	0.57 ± 0.13 0.36 ± 0.11 (n=130)	0.55 ± 0.14 0.37 ± 0.12 (n=38)	0.55 ± 0.12 0.39 ± 0.12 (n=58)	0.59 ± 0.11 0.35 ± 0.10 (n=117)
Total Cholesterol	5.27 ± 1.22 (n=158)	5.11 ± 1.14 (n=145)	5.12 ± 1.06 (n=130)	5.21 ± 0.97 (n=38)	5.22 ± 1.13 (n=58)	5.28 ± 1.20 (n=117)
Aspartate Transaminase	15.84 ± 7.16 (n=158)	16.89 ±10.45 (n=145)	17.21 ±10.04 (n=130)	17.46 ±12.71 (n=38)	16.38 ± 6.34 (n=58)	15.97 ± 7.20 (n=117)
Alanine Transaminase	13.13 ±10.88 (n=158)	15.2 ±15.18 (n=145)	15.57 ±15.91 (n=130)	15.97 ±16.82 (n=38)	14.12 ±10.66 (n=58)	13.17 ±10.73 (n=117)
Alkaline Phosphatase	111.99 ±81.96 (n=158)	119.41 ±78.1 (n=145)	117.64 ±85.81 (n=130)	116.62 ±76.85 (n=38)	125.67 ±97.45 (n=58)	107.63 ±75.63 (n=117)

1 The two largest distributional components of blood film examination area are presented here, each expressed in % contribution to the entire (100%) test results; the other components of test, not shown here (Mono, Eos, Baso and Band), made up the remaining contribution.

Note: In addition to the blood tests shown in this table, "red blood cell morphology" test results were also analyzed using "normal vs abnormal" comparison criteria developed by MDS Labs (see section 4.0 for details).

6.3 MORTALITY

The national mortality statistics provide an accurate population base of mortality in the areas. Mortality statistics for WS, EG, and Tec were collected from the Statistics Canada mortality database*. Mortality for the period 1971-1983 was tabulated by cause of death, age at death, and year of death. The death rates were standardized for age using the 1981 census data for Canada as the standard. The leading causes of mortality were the same (circulatory system; accidents and violence) in the three areas and showed no difference by sex.

Figures 6.3.1 - 6.3.3 give the age-adjusted, average annual mortality rates for all causes (total, female and male) for WS, EG, Tec, Ontario and Canada. Tables 6.3.1 - 6.3.3 provide the corresponding standard errors for these Figures**. WS death rates were consistently higher than EG but lower than Tec. A decreasing trend in mortality rates is evident in all three areas.

Figures 6.3.4 - 6.3.6 demonstrate average annual mortality rate for all cancers (total, female and male). Tables 6.3.4 - 6.3.6 provide the rates and corresponding standard errors. Again, the rates and trends are similar for WS, EG, and Tec and these are uniformly lower than Ontario and Canada.

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* Tecumseth data included: Beeton, Tottenham, and Township of Tecumseth according to Statistics Canada census definitions.

**standard errors not included in the Figures to maintain clarity of graph.

FIGURE 6.3.1: Age-Adjusted Average Annual Death Rate*

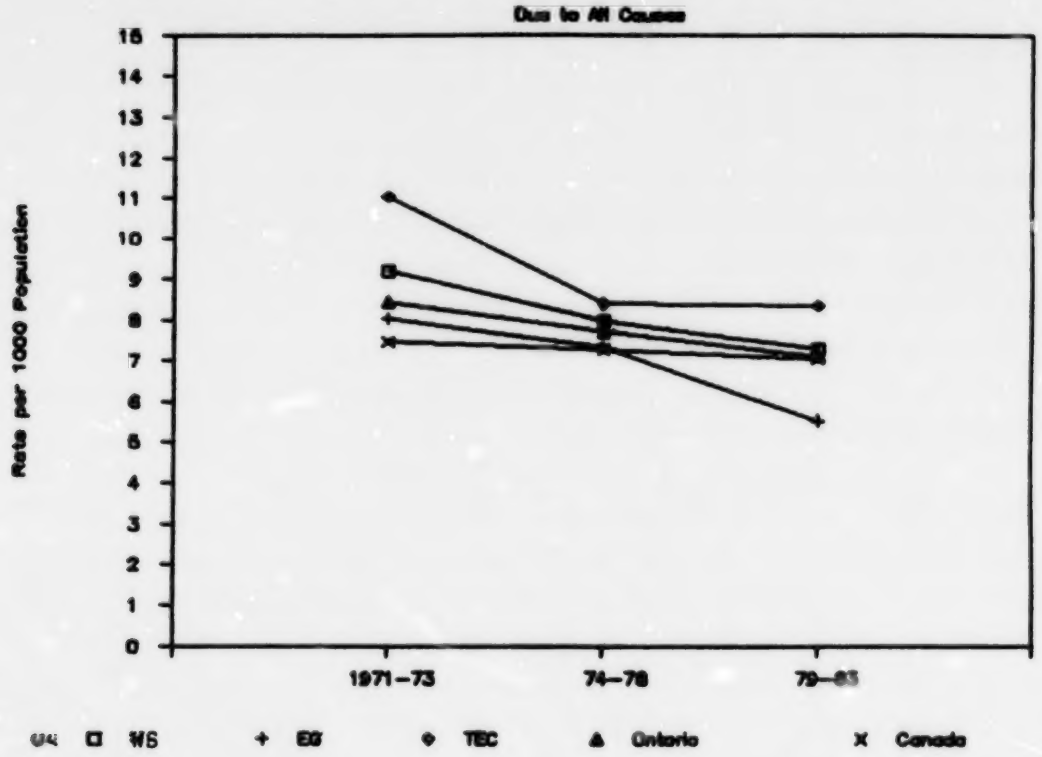

TABLE 6.3.1: AGE-ADJUSTED AVERAGE ANNUAL DEATH RATE DUE TO ALL CAUSES (per 1000 population)

LOCATION	1971 - 1973	1974 - 1978	1979 - 1983
Whitchurch-Stouffville	9.23 ± 0.91	8.19 ± 0.80	7.30 ± 0.73
East Gwillimbury	8.06 ± 0.93	7.34 ± 0.83	5.54 ± 0.66
Tecumseth	11.05 ± 1.27	8.43 ± 0.91	8.38 ± 0.86
Ontario	8.47	7.73	7.12
Canada	7.48	7.28	7.06

*Source: Statistics Canada Mortality Data, Vital Statistics Section, Ottawa; Age-adjusted using 1981 census data as the standard. See Table 6.3.1 for standard errors.

FIGURE 6.3.2: Age-Adjusted Average Annual Death Rate*

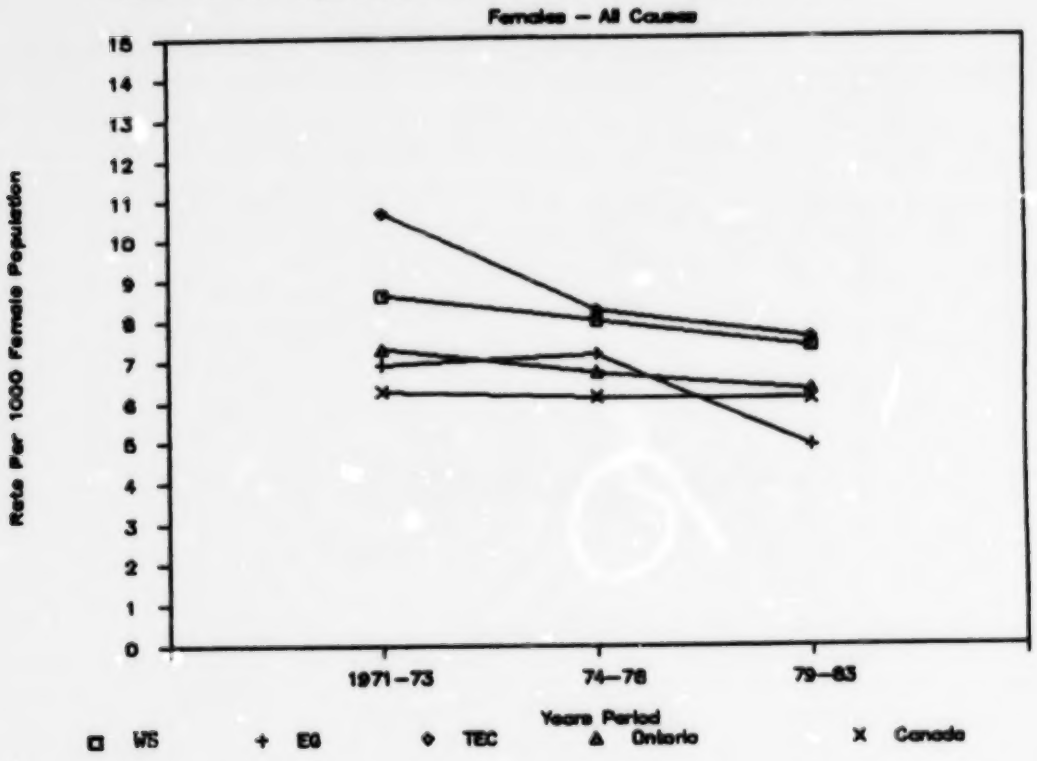

TABLE 6.3.2: AGE-ADJUSTED AVERAGE ANNUAL DEATH RATE FOR FEMALES DUE TO ALL CAUSES (per 1000 population)

LOCATION	1971 - 1973	1974 - 1978	1979 - 1983
Whitchurch-Stouffville	8.63 ± 1.25	7.99 ± 1.12	7.34 ± 1.05
East Gwillimbury	6.91 ± 1.23	7.16 ± 1.17	4.90 ± 0.90
Tecumseth	10.69 ± 1.80	8.25 ± 1.28	7.56 ± 1.16
Ontario	7.30	6.72	6.28
Canada	6.25	6.11	6.07

*Source: Statistics Canada Mortality Data, Vital Statistics Section, Ottawa; Age-adjusted using 1981 census data as the standard. See Table 6.3.2 for standard errors.

FIGURE 6.3.3: Age-Adjusted Average Annual Death Rate*

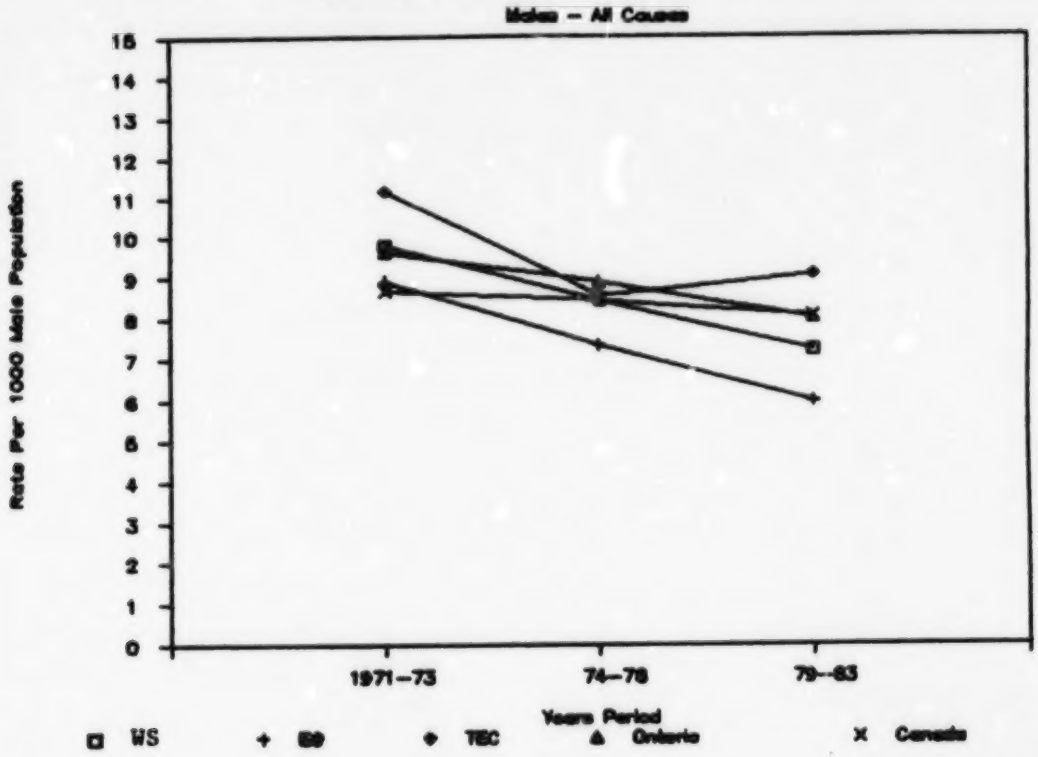

TABLE 6.3.3: AGE-ADJUSTED AVERAGE ANNUAL DEATH RATE FOR MALES DUE TO ALL CAUSES (per 1000 population)

LOCATION	1971 - 1973	1974 - 1978	1979 - 1983
Whitchurch-Stouffville	9.81 ± 1.31	8.46 ± 1.14	7.25 ± 1.03
East Gwillimbury	8.93 ± 1.37	7.37 ± 1.17	5.99 ± 0.96
Tecumseth	11.20 ± 1.78	8.57 ± 1.29	9.09 ± 1.25
Ontario	9.65	8.91	8.03
Canada	8.70	8.46	8.07

*Source: Statistics Canada Mortality Data, Vital Statistics Section, Ottawa; Age-adjusted using 1981 census data as the standard. See Table 6.3.3 for standard errors.

FIGURE 6.3.4: Age-Adjusted Average Annual Death Rate*

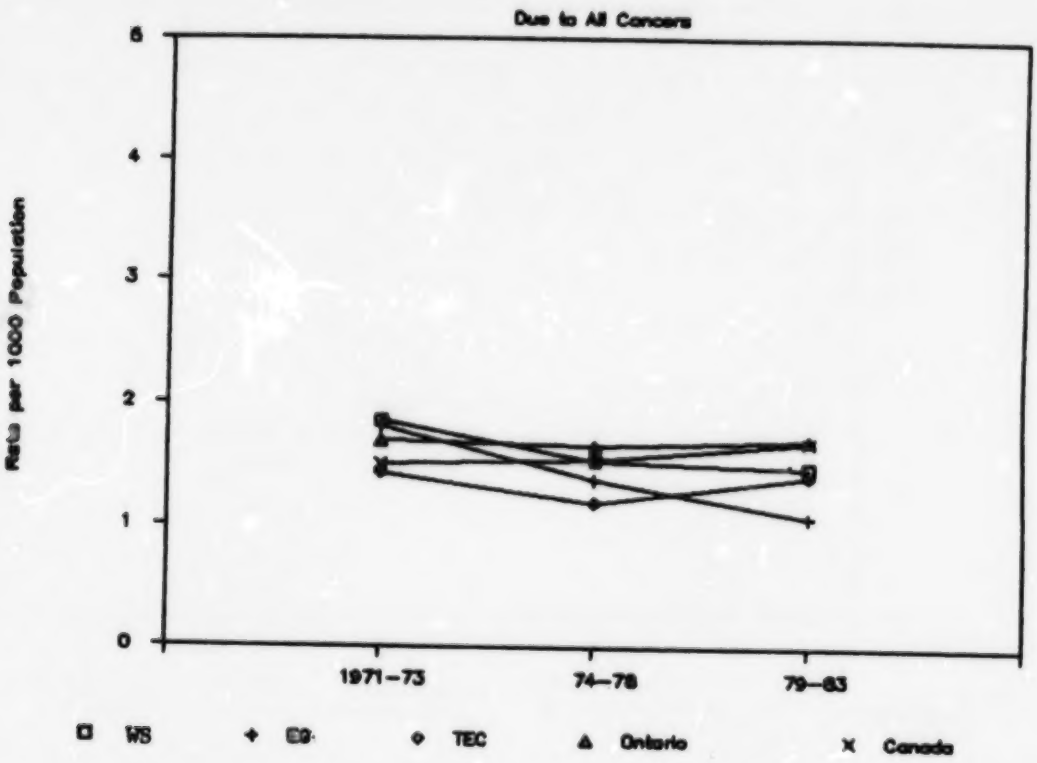

TABLE 6.3.4: AGE-ADJUSTED AVERAGE ANNUAL DEATH RATE DUE TO ALL CANCERS (per 1000 population)

LOCATION	1971 - 1973	1974 - 1978	1979 - 1983
Whitchurch-Stouffville	1.86 ± 0.41	1.54 ± 0.35	1.48 ± 0.33
East Gwillimbury	1.81 ± 0.44	1.38 ± 0.36	1.07 ± 0.29
Tecumseth	1.43 ± 0.46	1.19 ± 0.34	1.41 ± 0.35
Ontario	1.70	1.66	1.71
Canada	1.50	1.55	1.69

*Source: Statistics Canada Mortality Data, Vital Statistics Section, Ottawa; Age-adjusted using 1981 census data as the standard. See Table 6.3.4 for standard errors.

FIGURE 6.3.5: Age-Adjusted Average Annual Death Rate *

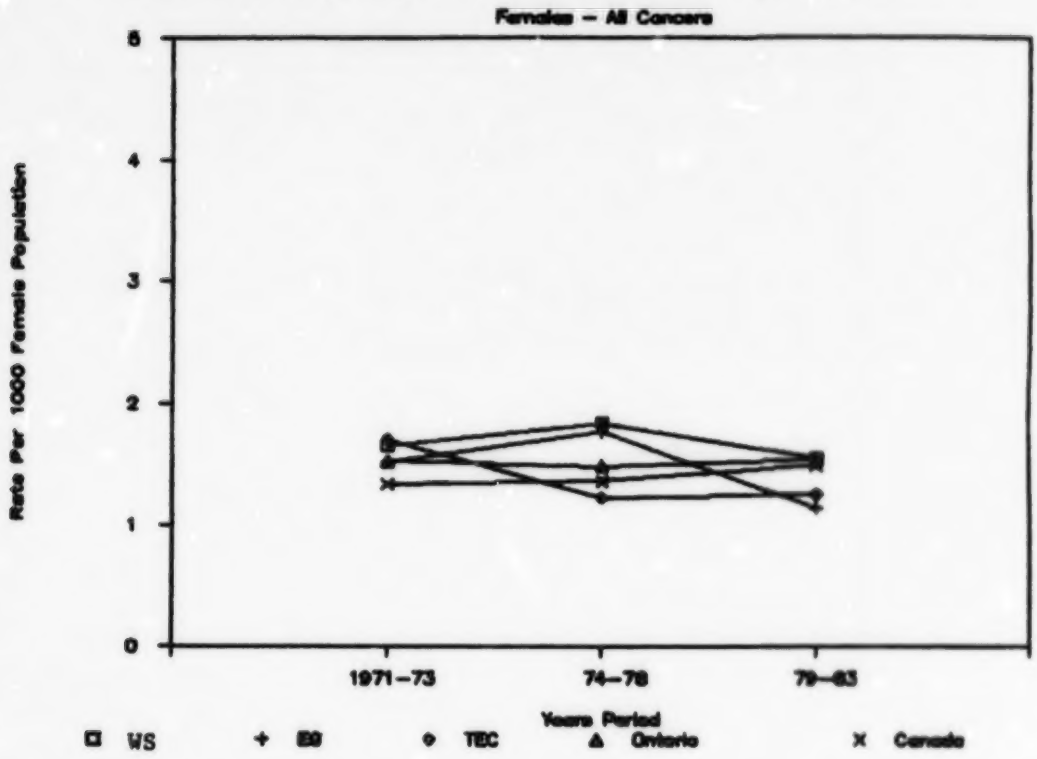

TABLE 6.3.5: AGE-ADJUSTED AVERAGE ANNUAL DEATH RATE FOR FEMALES DUE TO ALL CANCERS (per 1000 female population)

LOCATION	1971 - 1973	1974 - 1978	1979 - 1983
Whitchurch-Stouffville	1.65 ± 0.55	1.84 ± 0.54	1.54 ± 0.48
East Gwillimbury	1.52 ± 0.57	1.76 ± 0.58	1.13 ± 0.43
Tecumseth	1.70 ± 0.72	1.22 ± 0.56	1.24 ± 0.47
Ontario	1.52	1.48	1.53
Canada	1.34	1.36	1.48

*Source: Statistics Canada Mortality Data, Vital Statistics Section, Ottawa; Age-adjusted using 1981 census data as the standard. See Table 6.3.5 for standard errors.

FIGURE 6.3.6: Age-Adjusted Average Annual Death Rate *

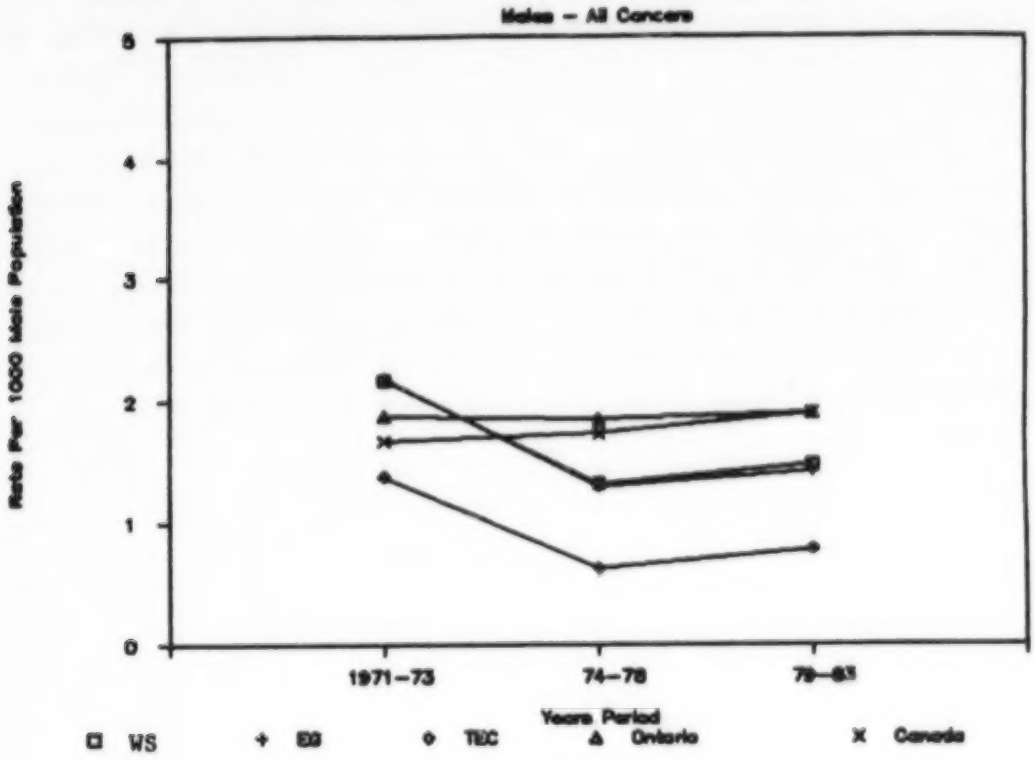

TABLE 6.3.6: AGE-ADJUSTED AVERAGE ANNUAL DEATH RATE FOR MALES DUE TO ALL CANCERS (per 1000 male population)

LOCATION	1971 - 1973	1974 - 1978	1979 - 1983
Whitchurch-Stouffville	2.17 ± 0.62	1.32 ± 0.45	1.48 ± 0.47
East Gwillimbury	2.17 ± 0.67	1.30 ± 0.49	1.42 ± 0.47
Tecumseth	1.38 ± 0.63	0.62 ± 0.35	0.78 ± 0.37
Ontario	1.87	1.85	1.90
Canada	1.67	1.73	1.90

*Source: Statistics Canada Mortality Data, Vital Statistics Section, Ottawa; Age-adjusted using 1981 census data as the standard. See Table 6.3.6 for standard errors.

Figure 6.3.7 demonstrates the age-adjusted, average annual mortality for lung cancer, and Figure 6.3.8 for breast cancer. Tables 6.3.7 - 6.3.8 provide the rates and corresponding standard errors for these figures. The lung cancer rates are lower than Ontario and Canada for the three areas, and slightly higher for WS compared to EG for the latter years. However, the differences between the three areas are not statistically significant. The breast cancer mortality rates are significantly higher for WS compared to EG and Tec for the 1974-78 period. For the 1979-83 period, there is no statistically significant difference in the breast cancer mortality rates between the three study areas or Ontario and Canada.

FIGURE 6.3.7: Age-Adjusted Average Annual Death rate *

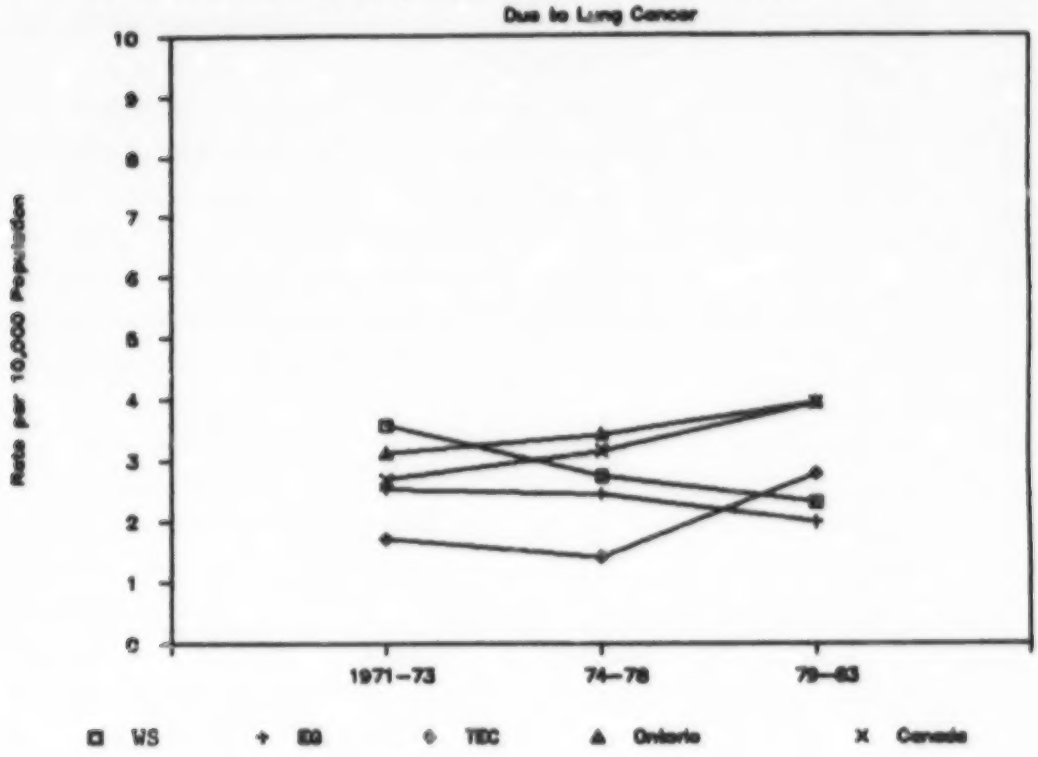

TABLE 6.3.7: AGE-ADJUSTED AVERAGE ANNUAL DEATH RATE DUE TO LUNG CANCER (per 10,000 population)

LOCATION	1971 - 1973	1974 - 1978	1979 - 1983
Whitchurch-Stouffville	3.56 ± 1.78	2.79 ± 1.46	2.30 ± 1.31
East Gwillimbury	2.52 ± 1.64	2.44 ± 1.52	1.97 ± 1.25
Tecumseth	1.70 ± 1.58	1.41 ± 1.18	2.77 ± 1.56
Ontario	3.11	3.42	3.94
Canada	2.68	3.15	3.92

*Source: Statistics Canada Mortality Data, Vital Statistics Section, Ottawa; Age-adjusted using 1981 census data as the standard. See Table 6.3.7 for standard errors.

FIGURE 6.3.8: Age-Adjusted Average Annual Death Rate*

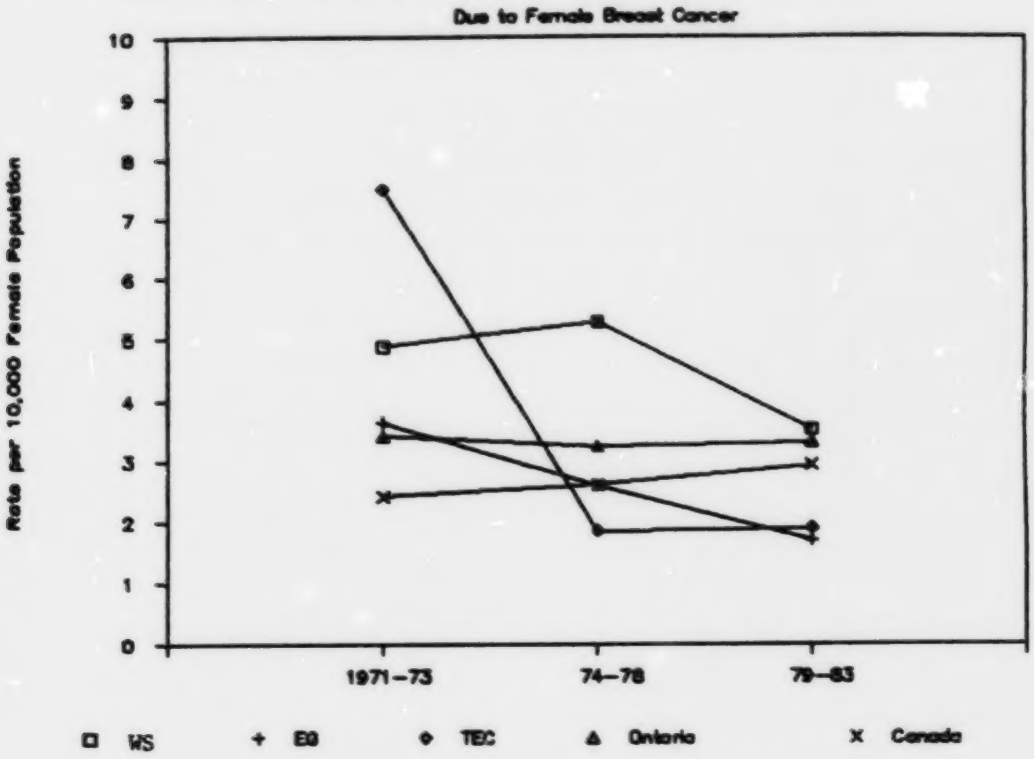

TABLE 6.3.8: AGE-ADJUSTED AVERAGE ANNUAL DEATH RATE DUE TO BREAST CANCER (per 10,000 female population)

LOCATION	1971 - 1973	1974 - 1978	1979 - 1983
Whitchurch-Stouffville	4.89 ± 2.97	5.29 ± 2.88	3.51 ± 2.33
East Gwillimbury	3.63 ± 2.81	2.59 ± 2.23	1.69 ± 1.67
Tecumseth	7.51 ± 5.03	1.85 ± 2.04	1.89 ± 1.90
Ontario	3.41	3.24	3.31
Canada	2.41	2.60	2.92

*Source: Statistics Canada Mortality Data, Vital Statistics Section, Ottawa; Age-adjusted using 1981 census data as the standard. See Table 6.3.8 for standard errors.

6.4 CONGENITAL ANOMALIES

The number of livebirths, stillbirths, spontaneous and therapeutic abortions, perinatal and early neonatal deaths, spina bifida, anencephaly, Down syndrome, and hydrocephaly were obtained for WS, EG, and Tec, as well as for the Regional Municipality of York and Simcoe County in which the study areas are located*. Because of the very small number of cases in many of these categories, five-year cumulative rates are plotted in Figures 6.4.1 - 6.4.8.

Perinatal mortality rates are higher in WS than EG or Tec during 1975-79, but are similar for the three areas during 1980-84. Early neonatal mortality rates in WS are lower than Tec during 1975-79 but higher in 1980-84; the WS rates are higher than EG for both periods. None of these differences are statistically significant. Data are not available for the period before 1975. Spontaneous abortion rates are similar or lower for WS than EG or Tec. Anencephaly and spina bifida were not reported in WS in this period. Down syndrome occurred 1 in 5000 livebirths in WS (2 occurrences) during the 10-year period. This was higher than the comparison areas, but not significant statistically.

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* Birth defects and other adverse reproductive outcomes were examined using the Congenital Anomalies Surveillance System (CASS). The data could not be disaggregated to WS-A, B, or C.

FIGURE 6.4.1: FIVE-YEAR CUMULATIVE STILLBIRTH RATE

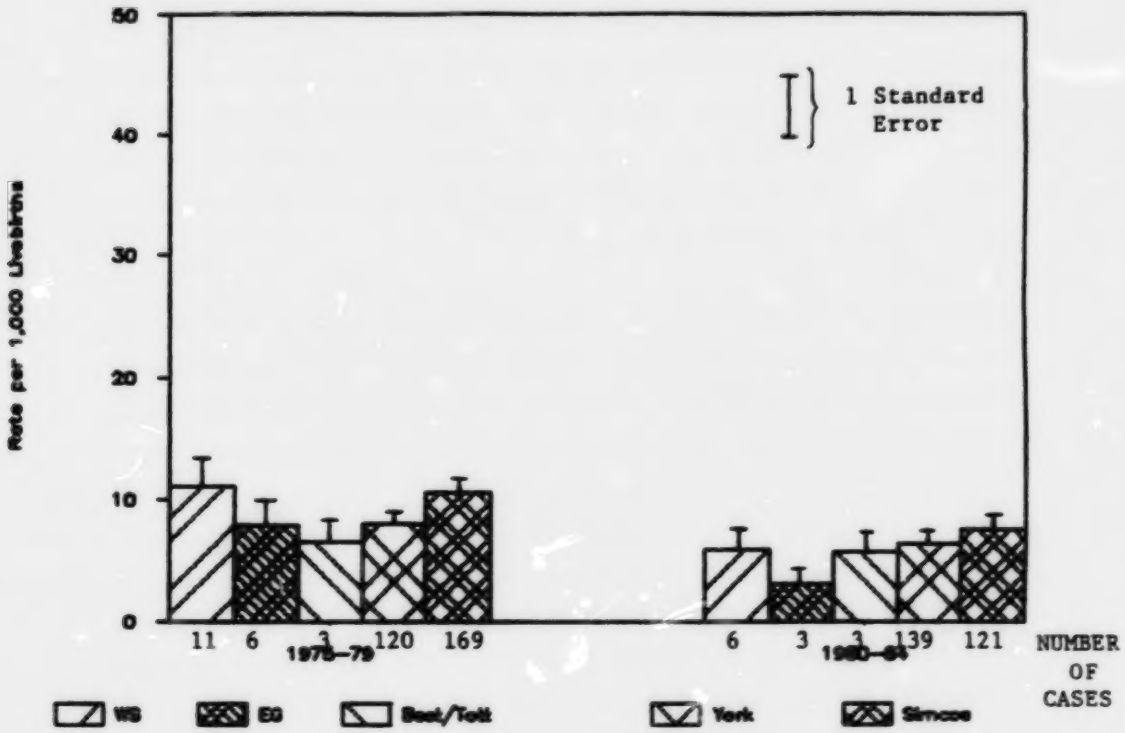


FIGURE 6.4.2: FIVE-YEAR CUMULATIVE PERINATAL DEATH RATE

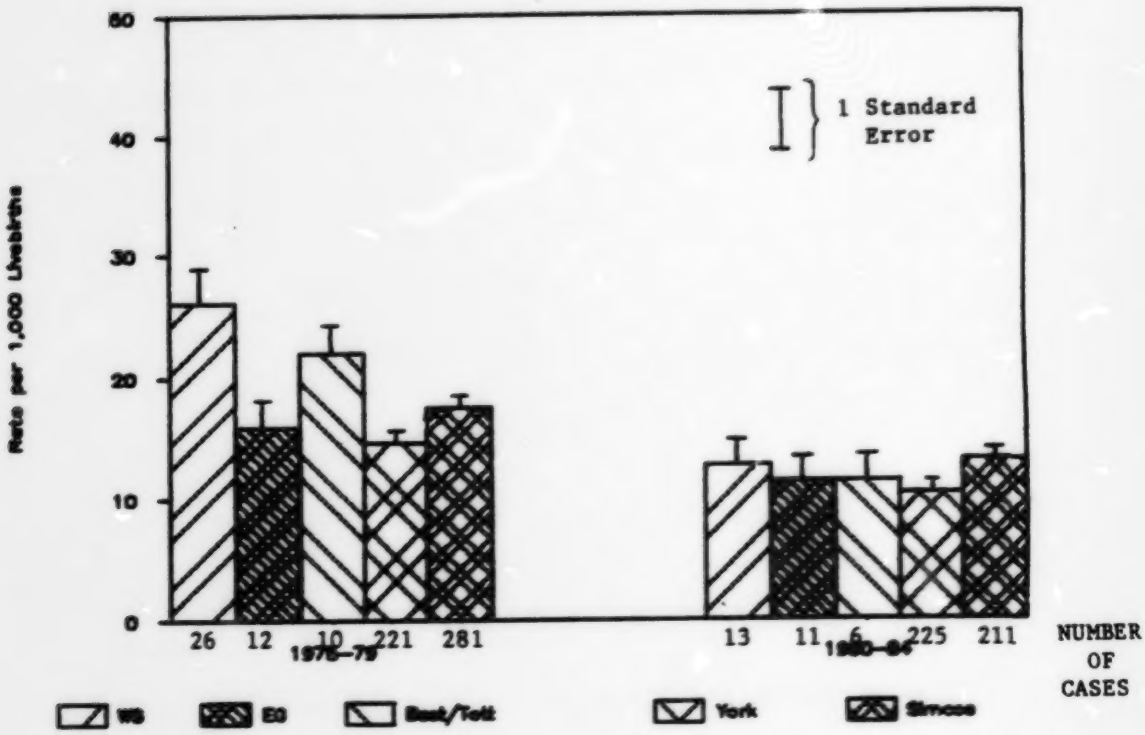


FIGURE 6.4.3: FIVE-YEAR CUMULATIVE EARLY NEONATAL DEATH RATE

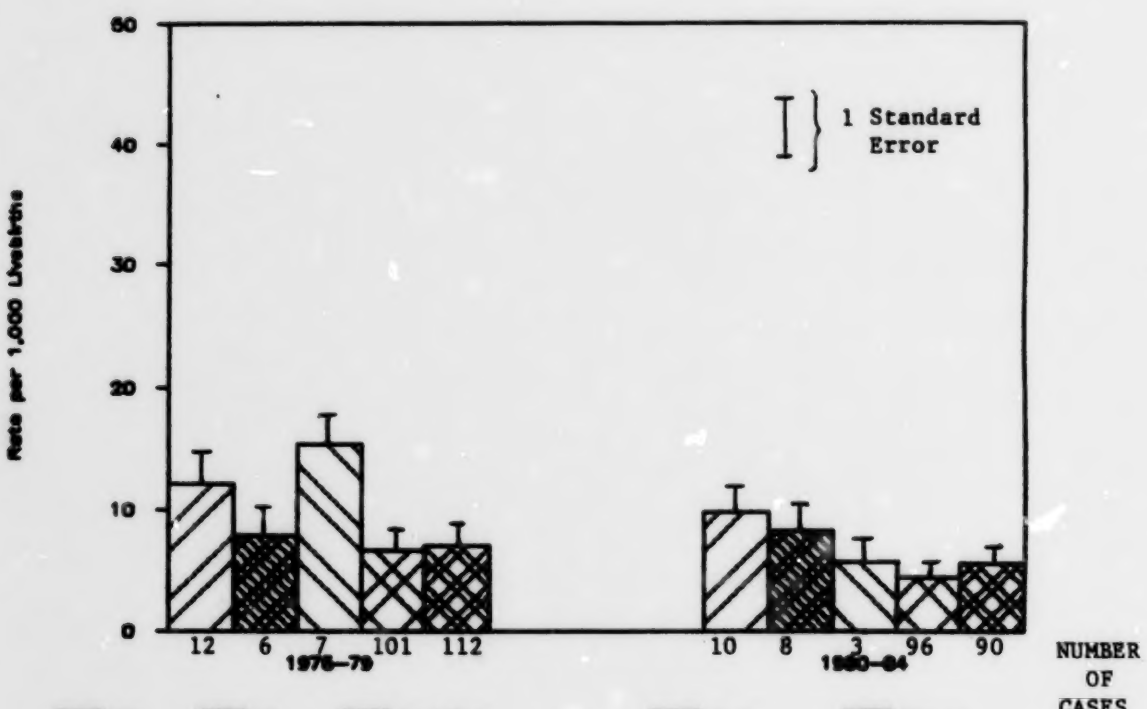


FIGURE 6.4.4: FIVE-YEAR CUMULATIVE SPONTANEOUS ABORTION RATE

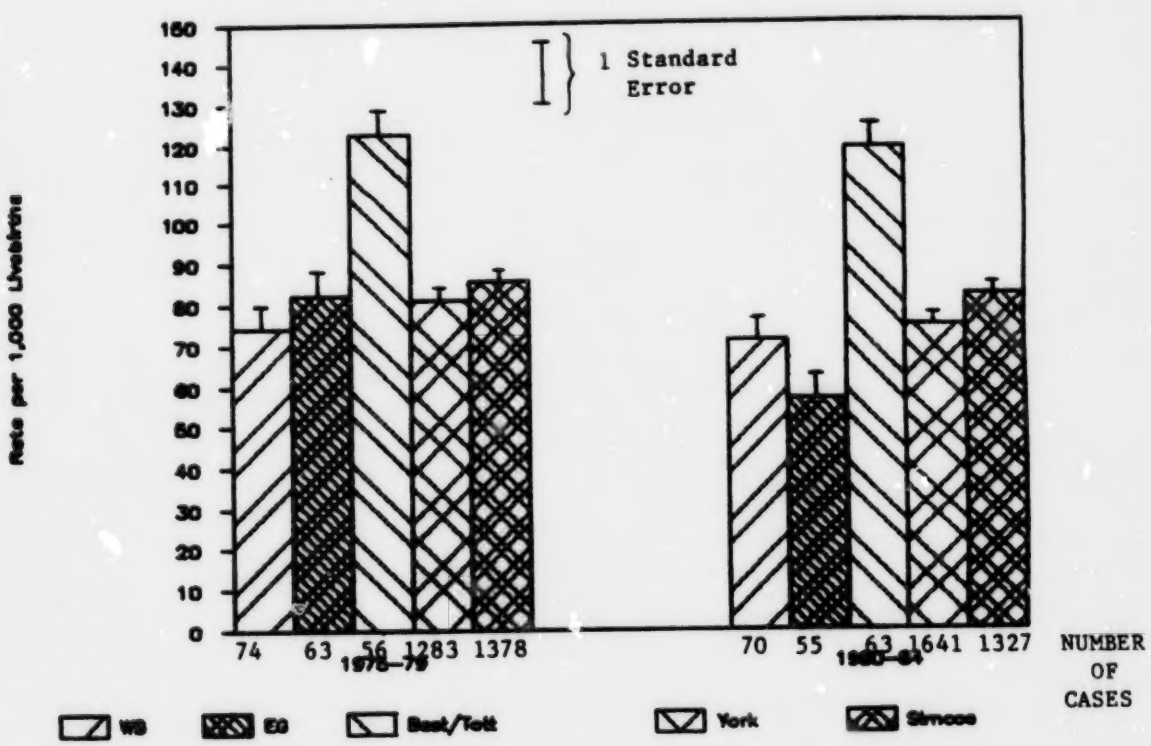
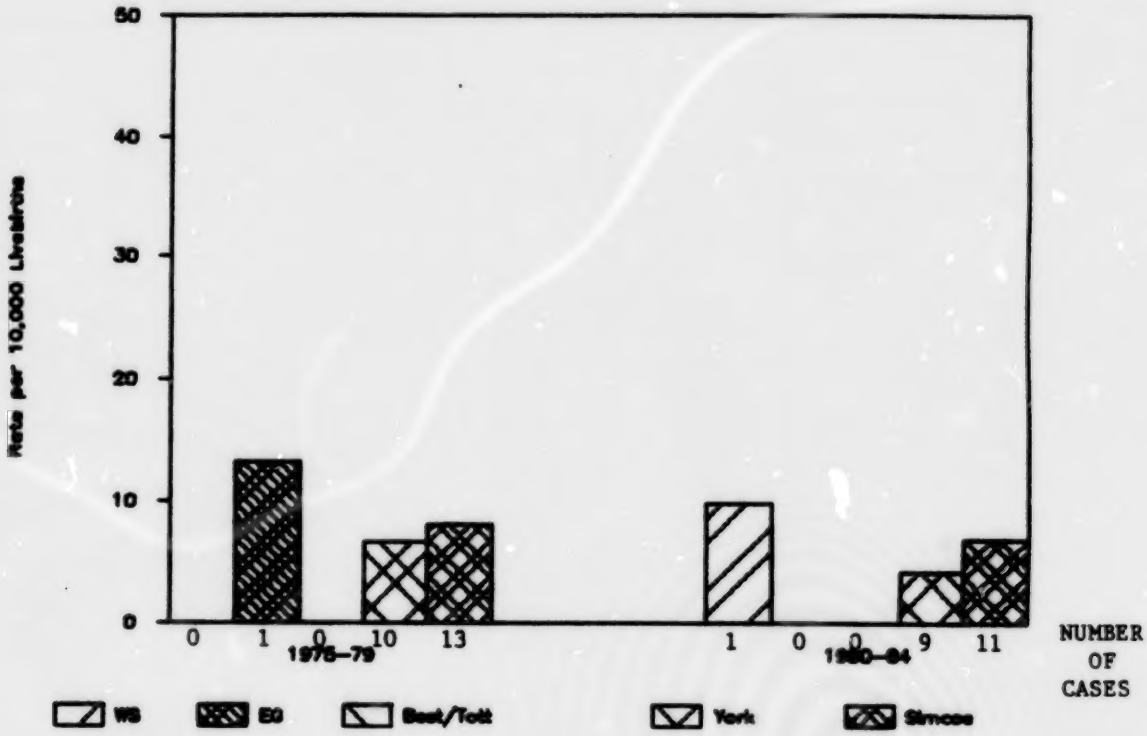
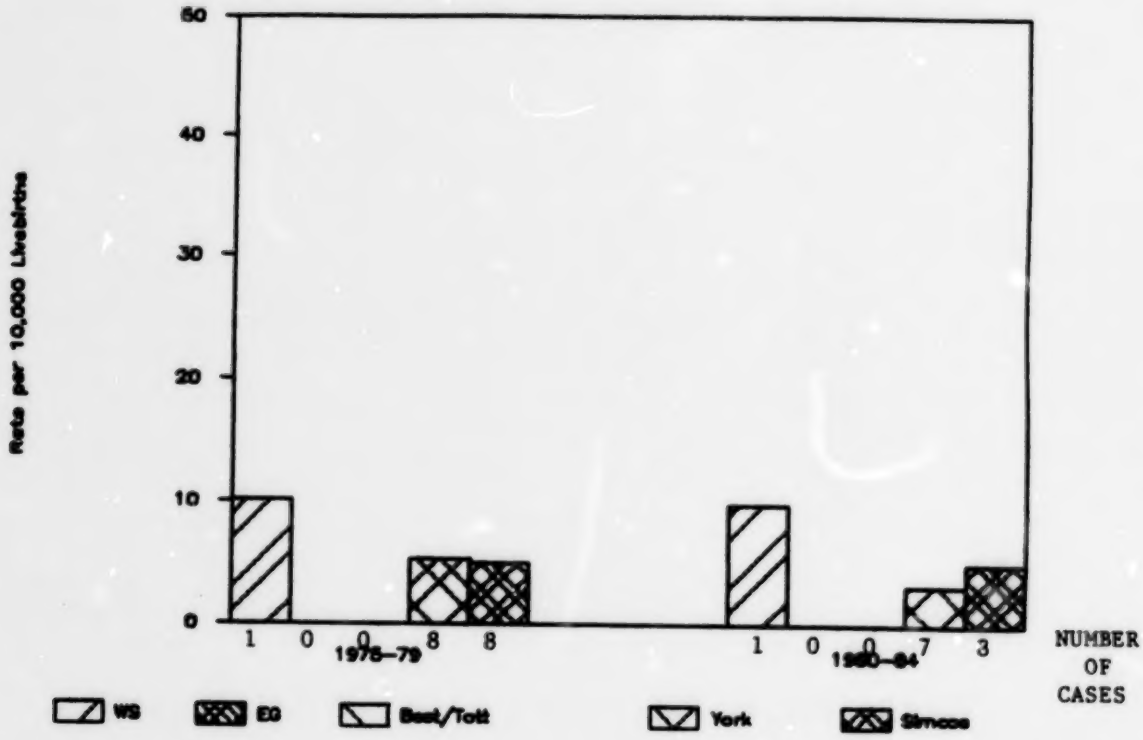


FIGURE 6.4.5: FIVE-YEAR CUMULATIVE ANENCEPHALY RATE *



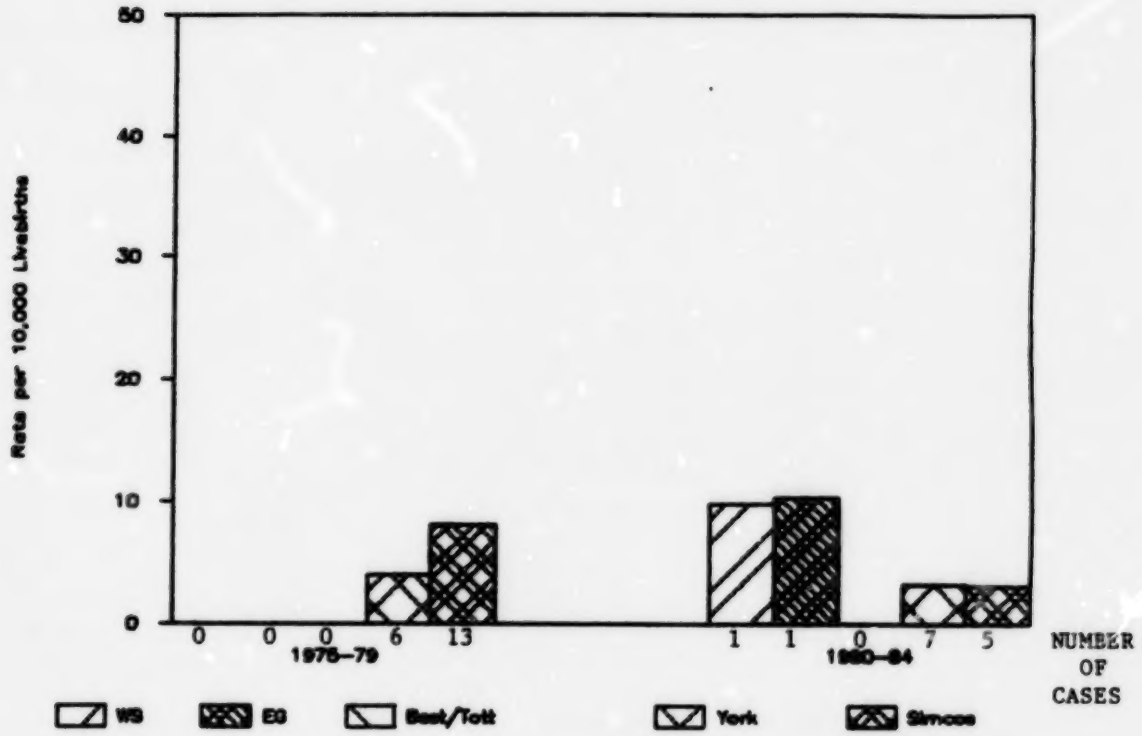
* number of cases too small for comparison; thus, standard errors not appropriate.

FIGURE 6.4.6: FIVE-YEAR CUMULATIVE DOWN SYNDROME RATE*



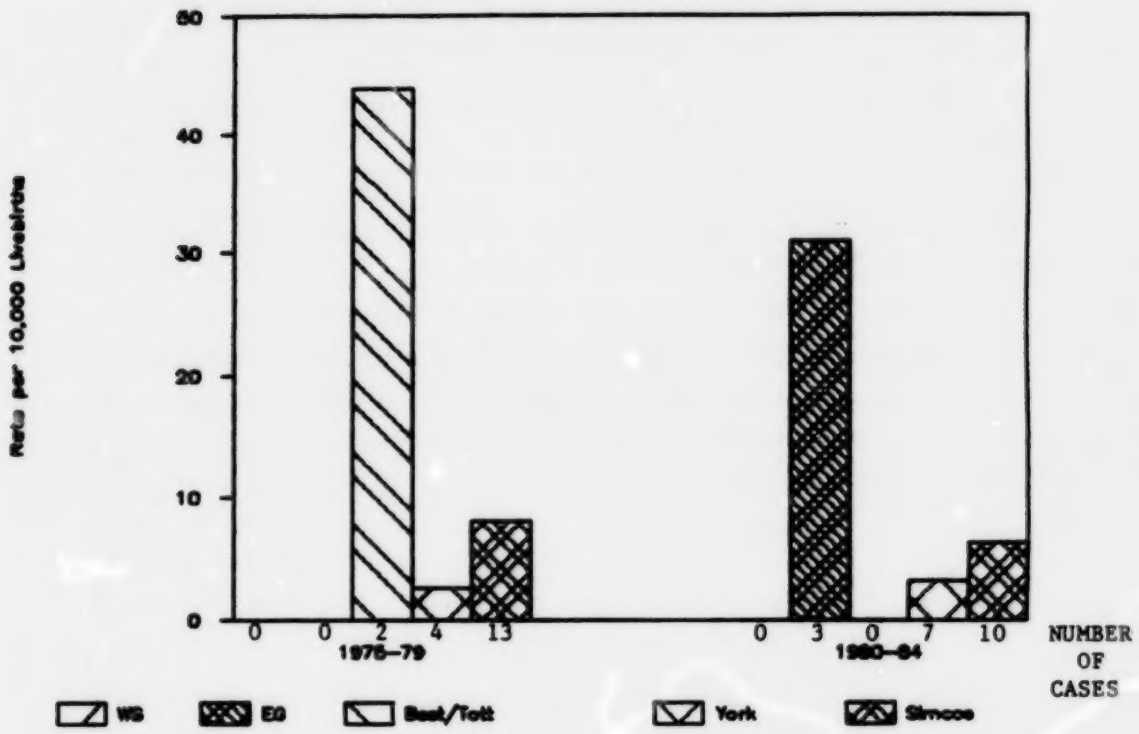
* number of cases too small for comparison; thus, standard errors not appropriate.

FIGURE 6.4.7: FIVE-YEAR CUMULATIVE HYDROCEPHALY RATE*



* number of cases too small for comparison; thus, standard errors not appropriate.

FIGURE 6.4.8: FIVE-YEAR CUMULATIVE SPINA BIFIDA RATE*



* number of cases too small for comparison; thus, standard errors not appropriate.

6.5 CANCER INCIDENCE

OCTRF provided data on cancer incidence. Tables 6.5.1 - 6.5.2 show the age-adjusted, annual average incidence rates for all cancers, cancer of lung for males, and cancer of breast for females. All the other site-specific data were not tabulated because of the very small number of cases*.

WS had lower cancer incidence rates than York Region and Simcoe County, but higher than EG and Tec. It should be pointed out that the registry is dependent on the completion of forms by the physician and many of the forms do not contain enough information such as postal code to be able to code to the township. Thus, the rates for the county or region are accurate, while the rates for the township levels may be underestimated (see section 5.2.4).

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* When the number of cases is very low, statistical comparisons are not appropriate for both validity and reliability reasons.

TABLE 6.5.1: ANNUAL AVERAGE AGE-ADJUSTED CANCER INCIDENCE RATES (± STD. ERROR) FOR ALL SITES 140-208 (EXCL. SKIN)

LOCATION	MALE	FEMALE
1979-83		
Whitchurch-Stouffville	249.8 ± 25.7	218.5 ± 24.0
East Gwillimbury*	78.2 ± 15.9	104.9 ± 18.1
Tecumseth* (includes Beeton and Tottenham)	108.8 ± 20.5	120.1 ± 21.6
York Region	265.9 ± 2.0	226.3 ± 1.7
Simcoe County	264.1 ± 6.2	228.3 ± 5.8

* possible underestimate due to lack of township residence codes in registry data.

Source: Epidemiology Unit, Ontario Cancer Treatment and Research Foundation.

TABLE 6.5.2: ANNUAL AVERAGE AGE-ADJUSTED RATES (± STD. ERROR) OF CANCER INCIDENCE IN MALE LUNG AND FEMALE BREASTS

LOCATION	MALE LUNG (ICD9: 162)	FEMALE BREAST (ICD9: 174)
1979-83		
Whitchurch-Stouffville	34.2 ± 9.5	69.6 ± 14.0
East Gwillimbury*	19.6 ± 8.1	27.2 ± 9.0
Tecumseth* (includes Beeton and Tottenham)	23.1 ± 9.9	26.2 ± 10.1
York Region	57.4 ± 0.9	61.7 ± 1.7
Simcoe County	61.0 ± 3.0	62.4 ± 3.1

* possible underestimate due to lack of township residence codes in registry data.

Source: Epidemiology Unit, Ontario Cancer Treatment and Research Foundation.

7.0 DISCUSSION OF RESULTS

7.1 SOCIODEMOGRAPHIC

Survey reported sociodemographic characteristics for the study area (WS) and the two comparison areas (EG and Tec) are similar. The response rates were similarly high in all three areas. The length of residency had a similar distribution in the main survey areas. In addition, the survey sub-areas WS-A,B,C were similar to the main areas. Awareness of problems with drinking water, potential sources of contamination and the effects on health were also similar for the three areas. Increased publicity and awakening of public interest in the study area of these concerns in the immediate past could have resulted in an over-reporting of health problems in the study area.

7.2 HEALTH STATUS - RESULTS OF THE SURVEY

The short-term health indicators on survey reported health status in the immediate past two weeks showed no significant trend in any of the categories for WS. Two-week prevalence of loss of appetite, upset stomach and diarrhea were significantly higher in WS than EG but not Tec. However, there was no increased prevalence of short-term health effects in the area closest to the landfill site (WS-A) compared to WS-B and WS-C.

The survey reported prevalence of long-term health conditions showed similar results. Of the 34 conditions listed, only two showed any statistically significant increase in reported prevalence in WS compared to EG and Tec or between WS-A,B, and C. These were intestinal problems and problems with the back. There was no relationship of reported prevalence to proximity to the landfill site or to the period of residency. Back problems had a lower prevalence in WS-A compared to the other two sub-areas.

High blood pressure, thyroid problems, serious trouble with legs/hips, and all other problems not listed in the 34 conditions, showed a slight increase in prevalence in WS compared to both EG and Tec, but these differences were not statistically significant. All the other chronic problems showed either similar prevalence rates for the three main survey areas, or higher prevalence compared to one and lower prevalence compared to the other comparison area.

Migraines, asthma, kidney disease, and serious trouble with bones, hands/feet showed consistently lower rates for WS compared to EG and Tec.

With respect to the sub-areas of Whitchurch-Stouffville, of the 34 chronic problems, none of the reported problems were significantly elevated in the area A, which had the highest potential for exposure. Considering that area A was sampled 100% (i.e., a complete census), this is an important finding. There were some non-respondents in the area but residents with chronic health problems would not be more likely than those without the condition to be a non-respondent. Arthritis, allergies/hayfever, migraines, and serious trouble with bones showed a reported prevalence in WS-A that was higher than the two other sub-areas, while 10 problems gave reported prevalence which were lower than the other sub-areas. Other chronic problems had a reported prevalence in WS-A which was very close or lower than WS-B and WS-C.

Table 7.2.1 summarizes the survey reported (short-term and long-term) health problems which had a significant ($p \leq .05$) difference in the index/study area (WS; WS-A) compared with the reference/other areas (EG, Tec; WS-B,C).

TABLE 7.2.1: SURVEY REPORTED HEALTH PROBLEMS WHICH HAD A SIGNIFICANT ($p \leq .05$) DIFFERENCE IN INDEX AREA COMPARED WITH REFERENCE AREAS

INDEX AREA: WS	COMPARED WITH*	
	EG	Tec
Upset Stomach	↑	→
Loss of Apetite	↑	→
Diarrhea	↑	→
Arthritis	↑	→
Skin Rashes	↓	↓
Intestinal Disorders	↑	↑
Serious Back Trouble	↑	↑

INDEX AREA: WS-A	COMPARED WITH*	
	WS-B	WS-C
Upset Stomach	↓	→
Headaches	↑	↑
Diarrhea	↓	→

*Legend: ↑: significantly higher ($p \leq .05$) in index area

↓: significantly lower ($p \leq .05$) in index area

→ : difference not statistically significant ($p > .05$)

The only chronic problem which showed increased prevalence (although statistically not significant) coherent with the hypothesis of proximity to landfill site and hence of exposure to contaminated drinking water was allergies/hayfever. This had a higher reported prevalence in WS compared to EG and Tec, as well as higher reported prevalence in WS-A compared to WS-B and WS-C. Reported prevalence was highest in WS during 1970-74, in line with the historical period of high chemical dumping at the landfill site and may reflect airborne irritants from the site.

Cancer is a major concern for residents exposed to potentially carcinogenic chemical waste. We reviewed each reported case. There was no difference in reported prevalence rates for leukemia or other cancers among WS, EG, and Tec, or among WS-A,B, and C. In spite of the small number of cancer cases reported over the past 20 years, we examined the distribution of the individual cases in each area and sub-area. There was an increased prevalence of reported breast cancer in WS compared to EG and Tec, and a decrease in the prevalence of other reported cancers. This survey result was confirmed by the registry-based population data. While there is no available evidence in the literature linking breast cancer to chemically-contaminated drinking water, it is, nevertheless, discomforting to note that there is an associated increase in mortality and morbidity due to breast cancer in more objective, routinely collected data (see sections 6.3 and 6.5 on mortality and morbidity respectively). This may need ongoing monitoring on a macro scale.

Thus, based on our results of the survey, it is our conclusion that there is no overall increase in the long-term health problems in WS as compared to EG or Tec. There was, however, an increase in short-term health conditions, hayfever/allergies, in WS during the period of high dumping.

One of the major concerns of the residents and a major emphasis in the terms of reference for this study was the outcome of pregnancies. Apart from the routine tabulation of data from the survey, we also looked into detailed information provided by the respondents for each pregnancy. We also verified a number of reported adverse outcomes of pregnancy from the

relevant medical records when they were available. Individual cases of reported adverse outcome were examined to identify severity, time of occurrence, family history, and other confounding variables.

One of the common indicators of problems with pregnancy, that of spontaneous abortion (miscarriage), was investigated in detail. The survey reported that the spontaneous abortion rate was higher in WS compared to EG and Tec, although this finding was not statistically significant. Many of the reported miscarriages were not, however, verifiable in the medical records (WS, 41%; EG, 46%; Tec, 44%). The reported stillbirth rate in WS was lower than EG, but slightly higher than Tec. These data were based on very small numbers of reported cases and, therefore, are subject to large statistical variations. The number of cases was too low to allow comparison of miscarriage rates between sub-areas. Considering the difficulties in diagnosing reported miscarriage, the relatively small excess of cases in WS as well as the problem of small numbers of cases, it is our conclusion that there is insufficient evidence to point to a problem in WS.

Questions concerning the types, rates, and/or trends of congenital anomalies were even more difficult to address and interpret, mainly because of the small number of cases, as well as the difficulty in defining and interpreting a 'birth-defect'. For example, a mole was considered a birth defect by some respondents. We analyzed each individually-reported birth defect and systematically defined and classified them into major and minor defects. While there was a slight increase in survey reported birth defects in the major category for WS (most of them heart defects), the differences were not statistically significant. The small number of birth defects observed in WS-A and WS-B did not permit valid comparisons within sub-areas. With the lack of corroborative evidence in trends in the survey data, no conclusions can be made based solely on these survey data.

7.3 ANALYSIS OF BLOOD

Results of the survey blood markers showed no significant differences between WS, EG and Tec, or between WS-A,B, and C. Thus, it is our opinion that there is no reason to suspect an adverse health outcome in WS on the basis of blood analysis.

7.4 CONFOUNDERS

The three areas were found to be similar in survey reported distribution for the common confounding variables, such as age, sex, smoking, occupational exposure, and physical activity, in addition to being similar in distribution for the use of drinking water from various sources. Since there was no significant difference in any of these variables, no adjusted rates have been reported herein, except for age-adjusted rates. Age and sex-specific rates were similar to the crude rates.

7.5 REPRODUCTIVE OUTCOMES

There were no statistically significant differences in any of the population database-generated outcome indicators (spontaneous abortion; stillbirth; and congenital defects, such as Down syndrome, spina bifida and anencephaly). This adds to the evidence collected by the survey that any small observed difference is due to statistical fluctuations in small numbers.

7.6 CANCER INCIDENCE

Due to the very small numbers, only summary information from the population registry-data (5 year incidence, age-standardized) is presented for all cancers and two specific sites: lung and breast.

WS had rates similar to the Province of Ontario and to the Regional Municipality of York. Both EG and Tec had a lower incidence of cancer of the lung and breast compared to Ontario as a whole and to the areas to which they belonged (Regional Municipality of York and Simcoe County, respectively). These lower incidence rates in EG and Tec could be due to reporting bias, since the cancer registry reports a high percentage (10-70 percent) of missing information on residency at the township level but not for the county. It is unclear why WS would not have a similar problem with underreporting compared to EG and Tec, except, perhaps, that it is closer to a major metropolitan area, Toronto. The increase in incidence/prevalence of breast cancer in females resident in WS compared to EG and Tec is, however, consistent between the three sources of data: the survey data, OCTRF data, and the mortality data. In spite of the lack of statistical significance, this suggests that the observed increase in WS may be real. The mortality and incidence data both suggest a downward-trend.

7.7 MORTALITY

Population database-generated mortality for WS, EG, and Tec was analyzed for the thirteen-year period (1971-1983). All cause mortality and cause-specific mortality were comparable between the three areas. WS had a slightly higher mortality rate, but trends over the 13 years under consideration were very similar. The only exception is mortality due to breast cancer, which showed a significant increase compared to EG and Tec during 1974-78 in WS.

8.0 CONCLUSIONS

The following conclusions were drawn in answer to the research questions posed in the objectives of the study.

1. There is no difference in overall mortality rates for WS compared to BC and Tec, as well as compared to Ontario and Canada;

2. There is no difference in leading diagnosis-specific mortality rates for WS compared to BC and Tec, Ontario and Canada, except for breast cancer during the 1974-78 period;

3. There is no difference in leading age and sex-specific mortality rates between WS, BC and Tec, as well as between WS, Ontario and Canada;

4. There is no difference in the prevalence of specific and non-specific health indicators between WS, BC and Tec, as well as between the defined sub-areas of WS;

5. Conclusions in 4. above are not affected by controlling for age, sex, occupational exposure, or other potentially confounding variables;

6. There is no difference in physiological markers, as measured by blood analysis, between WS, BC and Tec, as well as between the defined sub-areas of WS; and,

7. There is no relationship between the rate of occurrence of any adverse health outcome measured and the proximity of residence to the WS landfill site, the length of residence in the township, and the source of drinking water.

The overall conclusion is that there is little or no evidence that the residents of Whitchurch-Stouffville are experiencing any serious adverse health outcomes attributable to their residence being close to the (now inoperational) WS landfill site, and a possible exposure to chemical contamination of their drinking water.

9.0 RECOMMENDATIONS

Based on the results of the study survey and the examination of population registry-data from routine sources, and considering the concerns of the residents of WS, the following recommendations are made:

1. Since the results of the survey and population-based mortality and morbidity statistics show:

    - no severe short-term health conditions;
    - no significant increase in the prevalence of most chronic (long-term) illnesses; and,
    - no significant increase in the prevalence of adverse reproductive outcomes;

    and since the landfill site is no longer operational, therefore, **no further follow-up survey of health outcomes is necessary** for the WS area; and,

2. Since the source of contamination is now closed, it is unlikely that similar concerns would arise in the future. Most of the health problems arising from the landfill site, other than possibly some long latency cancers, should already have appeared. The only cancer which showed any significant increase in WS compared to EG and Tec was breast cancer. However, breast cancer has not been associated with drinking water contamination and, furthermore, the rates of breast cancer incidence and mortality were comparable or lower in WS than the provincial average, and all three areas (WS, EG, and Tec) showed a decreasing trend over the last ten years. The monitoring of population mortality and morbidity registry information can be used to detect and identify any possible future trends in health outcomes. In the unlikely event that the chemicals deposited in the site flow out and contaminate the water supply gradually, the monitoring of the water table around the landfill site by the Ministry of the Environment should serve as a warning sign to identify (future) possible contamination of drinking water. Therefore, it is recommended that **no further study of health outcomes be carried out to determine future health problems resulting from the possible contamination of drinking water.**

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